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THE UNIVERSITY OF ALBERTA

THE EFFECTIVENESS OF A MINIMUM SPEED LIMIT ON A TWO LANE HIGHWAY

BY

KENNETH MASON JARDINE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF CIVIL ENGINEERING

EDMONTON, ALBERTA

OCTOBER 1966

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled ....THE EFFECTIVENESS OF A MINIMUM SPEED LIMIT ON A TWO........ ....LANE HIGHWAY........

submitted by ....KENNETH MASON JARDINE........

in partial fulfilment of the requirements for the degree of MASTER OF ....SCIENCE........

Date ....OCTOBER 13, 1966....

ABSTRACT

The purpose of this investigation was to evaluate the effectiveness of a minimum speed limit on a two lane highway. Factors that were considered included; mean speeds, distribution and dispersion of vehicle speeds, the incidence of overtaking and accident occurrence.

Four basic tests were used to evaluate these factors. They were; day and night speed observations, travel time measurements, volume and accident analysis and roadside interviews.

The tests were performed on a thirty-three mile section of the Trans-Canada Highway in Manitoba. Minimum speed signs were erected and traffic was advised of an alternate route available for slow moving vehicles. For control purposes the tests were duplicated on a nearby but separate section of the same highway.

Results of the tests indicated similar daytime speed changes on both test and control section which could not be attributed to the effects of the minimum speed limit. Changes in low speeds, mean speeds and normality of distribution were, however, detected on the test section at night. Analysis of accident occurrence was inconclusive due to a short "after" period but little effect from the speed limit change was indicated. Driver opinion was found to be favourable toward minimum speed limits.

The principal conclusions from the test were; 1) minimum speed limits on a two lane highway have little effect on operating speeds, and 2) an index of overtaking which proved to be a reliable measure of passing activity was developed in this study.

ACKNOWLEDGEMENTS

The author wishes to extend his appreciation to Associate Professor J. J. Bakker of the Department of Civil Engineering at the University of Alberta, Edmonton for his interest, guidance and advice during the preparation of this thesis.

The assistance and sponsorship of the Highways Department, Province of Manitoba is acknowledged. The interest and help of the several members of the Planning Division who were involved in field tests was essential to the completion of the project.

The complete co-operation and assistance of the Traffic Section of the Manitoba Division of the Royal Canadian Mounted Police was both valuable and necessary.

Thanks are extended to Miss Pauline Shumyla who was so generous with her time.

Special gratitude is offered to Mr. L. W. Blackman, Assistant Deputy Minister, Manitoba Highways Department for his continued encouragement and support throughout the programme.

The author wishes to express appreciation, also to the Highway Traffic and Co-ordination Board of Manitoba whose favourable decision was a necessary prelude to the research.

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CHAPTER I

INTRODUCTION

Although maximum speed limits are in common use in many parts of the world, minimum speed limits are comparatively rare. Authorities hesitate to impose minimum speed limits because of a fear that by so doing they will encourage some drivers to increase their rate of speed beyond their capabilities or that of their vehicles, and that this will result in an increased accident experience. It is also feared that certain slow moving vehicles would be denied the right to use the highways.

On the other hand there is a general feeling that control of slow moving vehicles is required to avoid unnecessary impediment to the movement of traffic. Concern has also been expressed that slow vehicles are a prime cause of accidents.

Minimum speed limits have had occasional use as a device to control the slow vehicle. Most traffic jurisdictions have adopted legislation similar to Section 11-804 of the "Uniform Vehicle Code" ★ (21) which states: (a) "No person shall drive a motor vehicle at such a slow speed as to impede the normal and reasonable movement of traffic except when reduced speed is necessary for safe operation

★ Numbers in parentheses refer to Reference List

or in compliance with law." Many jurisdictions feel that this is sufficient to control the slow driver but others include in their legislation a form of (b) of the above section which states in part: "Whenever ..... local authorities determine on the basis of an engineering and traffic investigation that slow speeds on any part of a highway consistently impede the normal and reasonable movement of traffic .... such local authority may determine and declare a minimum speed limit ..."

Despite the occasional use of minimum speed limits, a complete search of literature on the subject indicates that no research has been reported regarding the determination of the effects of a minimum speed limit either on driver behaviour or accident rates.

CHAPTER II

THEORETICAL CONSIDERATIONS

GENERAL

Baerwald (4) defined speed as "the rate of movement of a vehicle generally expressed in miles per hour" in North America. He pointed out, however, that the word "speed" is generally taken to refer to high speed or excessive speed. Years of exposure to safety slogans which proclaim " Speed Kills" or "Slow Down and Live" have affected the public concept of vehicle movement. The popular belief is that an increase in the maximum allowable speed will result in increased travel speeds and that this in turn will increase the accident rate. Wiley (37) reporting a study in which posted speed limits were varied from 20 to 35 m.p.h. concluded; "Traffic consistently ignores posted speed limits and even the absence of speed limit signs, and runs at speeds which drivers consider reasonable, convenient and safe under existing conditions." "An Informational Report on Speed Zoning" (13) prepared by the Institute of Traffic Engineers reports .... "collision frequencies and accident rates have been reduced by raising speed limits to realistic levels."

PERCENTILE SPEEDS

The above findings have resulted in a common practical method of

establishing maximum speed limits based on the actual prevailing speed of traffic. Maximum speed limits are commonly based on the 85th percentile speed--the speed below which 85 percent of the vehicles are travelling. The 85 percentile value has been chosen as an appropriate speed limit because it occurs approximately at the knee of the cumulative distribution curve. This means that raising the speed limit higher than the 85 percentile would affect a decreasing number of vehicles.

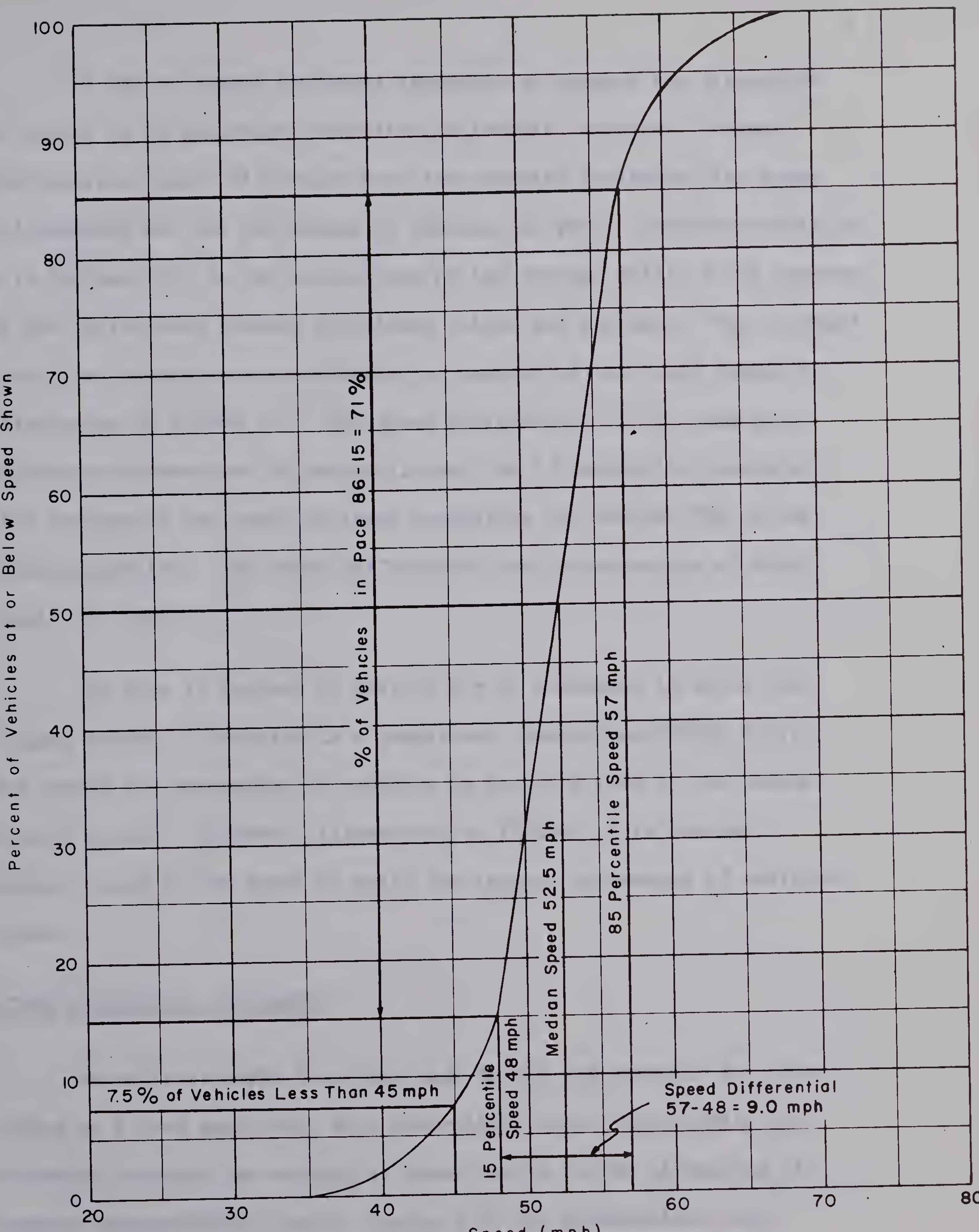
Numerous extensive before and after studies have confirmed that the use of the 85 percentile produces a reasonable and practical speed limit with a minimum of enforcement difficulties.

Similarly the 15th percentile approximates the lower knee of the curve and might therefore be a practical guide to setting minimum speed limits.

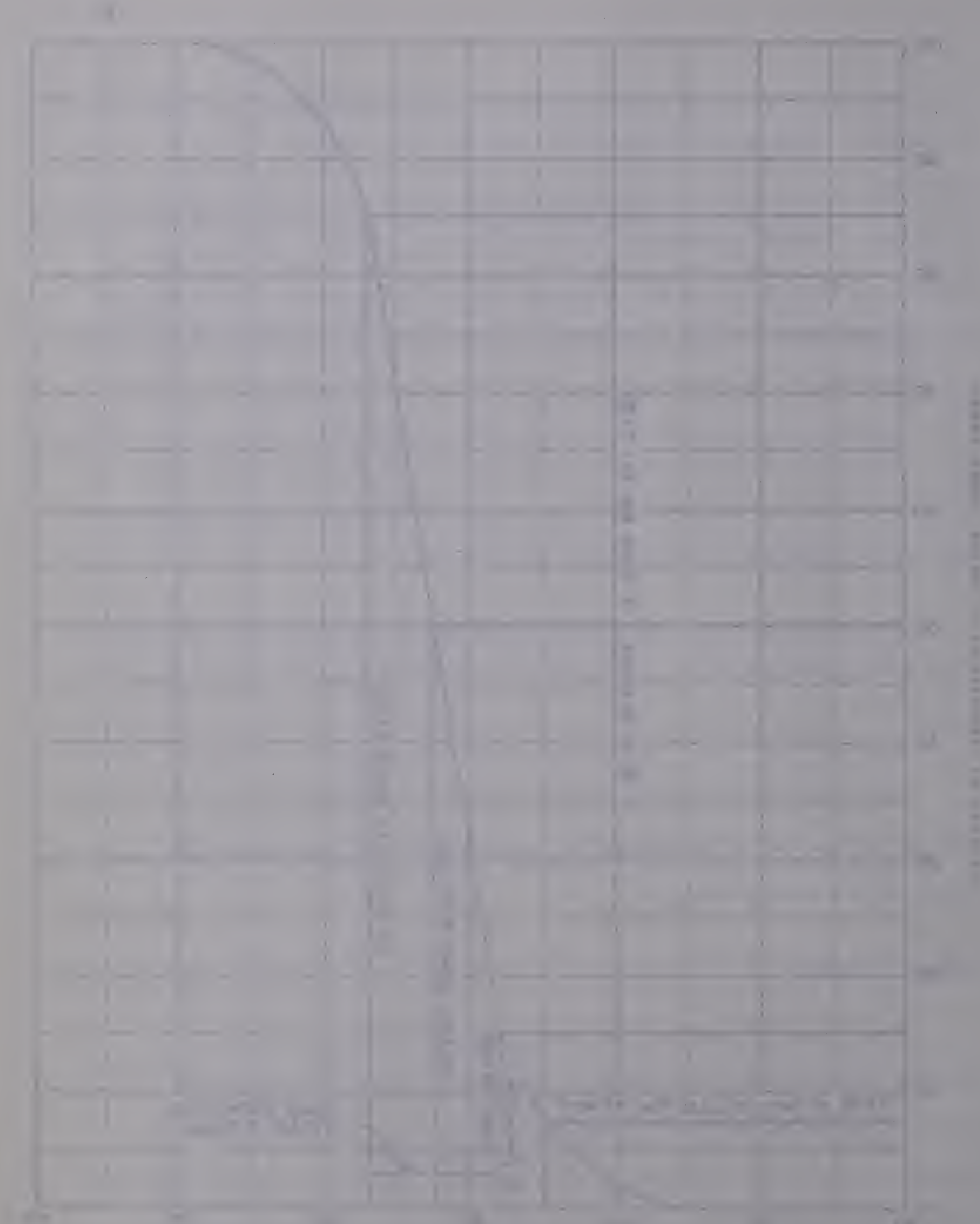
These percentile speeds are illustrated in FIGURE 2.1. Also shown is the median or 50 percentile speed which is a useful approximation of the average speed.

SPEED DISPERSION

The Bureau of Public Roads report (28) indicates that the relative speed of pairs of vehicles travelling in the same direction can be an important element in accident reduction. As an example, 30% of such vehicle pairs which were involved in accidents were travelling at a speed difference in excess of 30 m.p.h., while only 1% of normal highway traffic exceeded that speed difference.



TYPICAL CUMULATIVE FREQUENCY CURVE

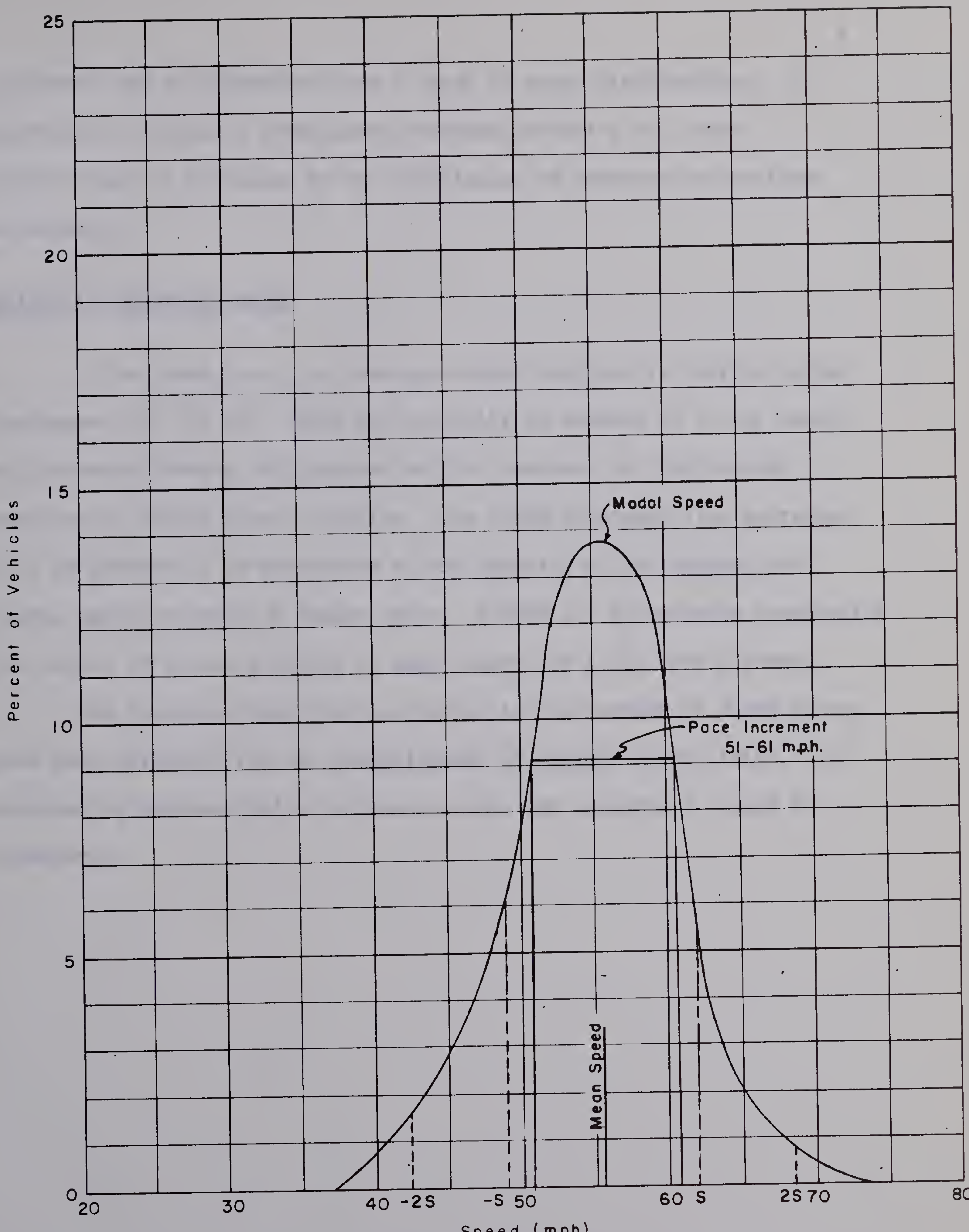


It may be deemed advisable therefore to measure the dispersion of speeds as an important indication of traffic behaviour. Common indicators of speed dispersion are, the standard deviation, the speed differential and the percentage of vehicles in pace. Standard deviation s is defined (26) as the square root of the average value of the squares of the differences between individual values and the mean. One standard deviation encompasses approximately 68 percent of the total sample as illustrated in FIGURE 2.2. The speed differential is the numerical difference between the 85 percentile and the 15 percentile speeds and thus represents the range of speed containing the central 70% of the speed population. The speed differential has the advantage of being simple to compute.

The pace is defined as that 10 m.p.h. increment in which the largest number of vehicles in a sample are travelling (FIGURE 2.2). The larger the percentage of vehicles in pace the less is the dispersion of speeds. The modal, illustrated in FIGURE 2.2 is the most popular speed or the speed at which the largest percentage of vehicles travel.

OTHER THEORETICAL APPROACHES

Recently attempts have been made to set the warrants for speed zoning on a less empirical, more theoretical base. Oppenlander (24) attempted to relate the setting of speed limits to the minimizing of highway transportation costs. Taylor (33, 34) hypothesized that sections of highway where speed zoning would be helpful in reducing



TYPICAL HISTOGRAM

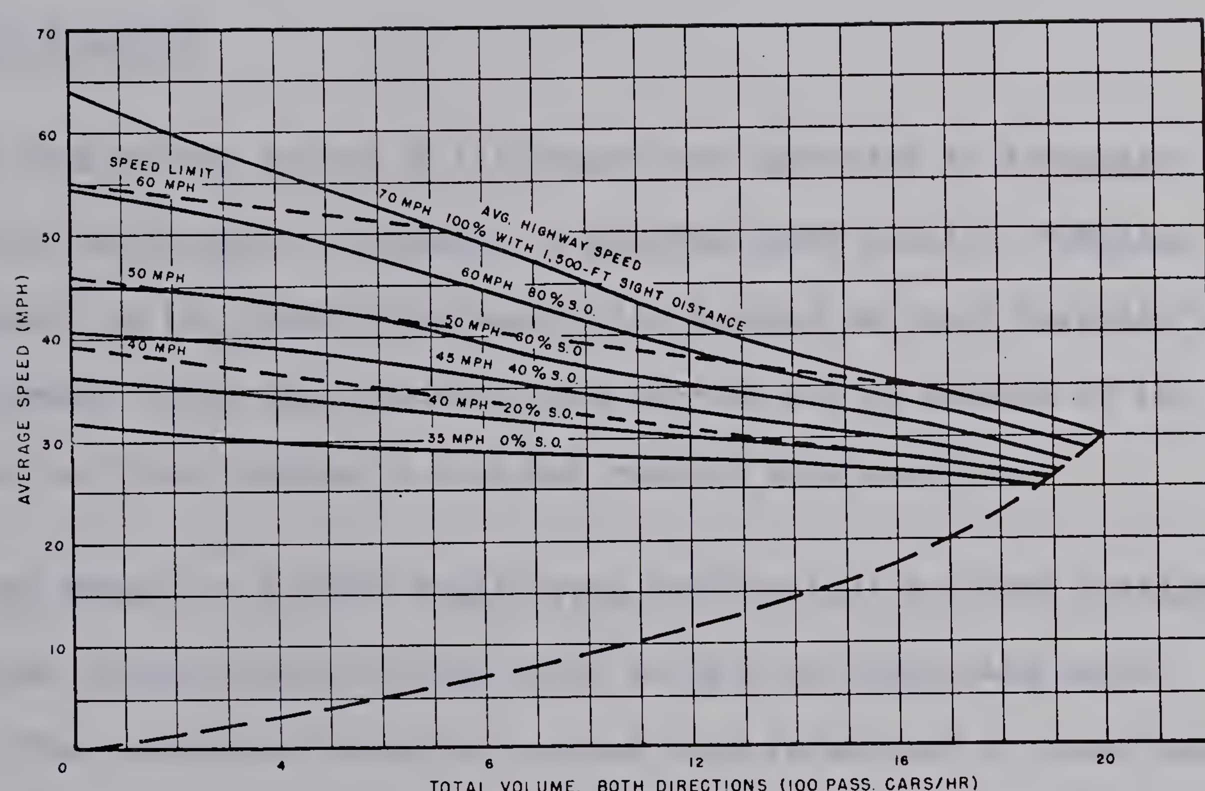
Figure 2.2

accidents can be determined from a study of speed distributions. In particular he found a relationship between normality of a speed distribution as indicated by the coefficient of skewness and accident occurrence.

EFFECT OF VOLUME ON SPEED

It has been found that average speeds decrease as traffic volume increases (10, 17, 26). This can logically be assumed to be the result of increased passing difficulties and the tendency for fast moving vehicles to follow slower vehicles. The range of speeds also decreases (17) as congestion is approached at the capacity of the highway and travel speeds approach a single value. FIGURE 2.3 illustrates graphically the effect of volume increase on mean speeds for a two lane highway.

The foregoing described approaches to the concept of speed zoning have been developed for the establishment of maximum speed limits. In considering minimum limits the same concept and parameters could be considered.



From "Highway Capacity Manual" (10)

TYPICAL RELATIONSHIPS BETWEEN VOLUME AND MEAN SPEEDS ON TWO LANE HIGHWAYS

Figure : 2 · 3

CHAPTER III

PRELIMINARY STUDIES

LITERATURE RESEARCH

A preliminary search of literature was conducted to determine the state of knowledge with respect to minimum speed limits. McMillan (18) reported on the overall minimum limits imposed on South Carolina's highway system. Spot speed studies were carried out in advance of the limits but no after studies or accident records were reported.

The Manual of Traffic Engineering Studies (12) provided detailed descriptions of test methods which could be used for measuring speed changes. The literature contained a great many references to experience with maximum speed limits, to typical speed distributions, and to speed of traffic under a variety of weather and road conditions.

LETTER SURVEY

In preparing the background for this investigation a letter survey was sent out to twenty-five traffic jurisdictions in Canada and the United States of America. FIGURE 3.1 is a copy of the letter of request and Table 3-1 a summary of the eighteen replies received. Although ten of the eighteen jurisdictions have legislation enabling the imposition of a minimum speed limit only five have imposed them and none have conducted

303 Legislative Building,

Winnipeg 1, Manitoba.

March 22, 1962.

Dear Sir:

In our search for methods to promote efficient and safe movement of Highway traffic we have come to the consideration of the value of <u>minimum</u> speed limits.

In order to determine the extent of experience in other jurisdictions we are requesting any information, publications, or comments that you may have available regarding the use of minimum speed limits.

I would like to thank you in advance for your kind co-operation.

Yours very truly,

K. Jardine,

Traffic Engineer.

KJ/ps

FIGURE 3.1

LETTER OF REQUEST FOR SPEED LIMIT INFORMATION

TABLE 3-I

SUMMARY OF REPLIES TO LETTER SURVEY 1962

Jurisdiction	Have Enabling Legislation	Have Tried Min. Limits	Are Considering	Have Considered Research	Comments
British Columbia	no	no	no	no	see no value in minimum speed limit
Bureau of Public Roads	no	no	no	no	no published research
Connecticut	no	no	no	no	-
Illinois	yes	only where vehicle types are controlled	yes	no	problems anticpated with weather, congestion & slow moving vehicles
Maryland	yes	no	no	no	problem with commercial vehicles on steep grades
Minnesota	yes	no	yes	no	believe spread between minimum and maximum should be 15 m.p.h.
Nevada	yes	no	no	no	only applicable to expressways
New Brunswick	yes	no	yes	no	not yet required
Newfoundland	yes	40 m.p.h. on Trans-Canada	-	no	no convictions
North Dakota	yes	one short section	no	no	no convictions
Nova Scotia	no	no	yes	no	will try to control Sunday drivers
Ohio	yes	two city bypass freeways	yes	no	intended only for vehicles capable of high speed

TABLE 3-I

SUMMARY OF REPLIES TO LETTER SURVEY 1962

Jurisdiction	Have Enabling Legislation	Have Tried Min. Limits	Are Considering	Have Considered Research	Comments
Oklahoma	-	no	-	Compiled present practice on Interstate highways	
Ontario	no	no	no	no	congestion makes it impossible
Prince Edward Island	no	no	no	no	still have horse drawn vehicles
Saskatchewan	yes	no	yes	no	problems with farm machinery
South Carolina	yes	yes	-	no	63 summons in 8 months
Texas	no	no	no	no	-

research into their effectiveness.

The Oklahoma State Highway Survey (22) of present practices on Interstate highways indicates that nine of fifty jurisdictions now use minimum speed limits and that eighteen jurisdictions recommend their use on the Interstate system.

Comments received from those opposed to the use of minimum speed limits cited problems relating to vehicles such as farm equipment, house trailers, parades, old cars, overweight trucks operating under permit and trucks on steep grades all of which might be unable to maintain the required speeds. Also mentioned were problems of congestion and adverse weather conditions which make maintenance of speed impossible. The correspondent from Ontario expressed the opinion that the purpose of minimum speed limits is to prohibit certain classes of vehicle from utilizing the road without saying so directly.

Those in favour or who have tried minimum speed limits cite "control of the slow driver" as the chief aim and advantage. Some anticipated a more uniform range of speeds with resultant increase in highway capacity. The correspondent from Ohio reported the use of ordinances excluding vehicles incapable of a reasonable speed from using the higher class road facilities.

This letter survey served to illustrate the differences of opinion that existed among traffic authorities as to the uses and

usefulness of minimum speed limits. The obvious lack of fundamental knowledge as to the effects of these limits is the justification for this investigation.

ACCIDENTS

FIGURE 3.2 relates accident involvement rates to travel speeds on rural highways. The extremely high accident involvement of slow moving vehicles (below 45 m.p.h.) is evident. The report (28) from which FIGURE 3.2 was extracted found that 44.3% of vehicle accident involvements occurred at travel speeds less than 42 m.p.h. despite the fact that only 12.3% of vehicle miles were travelled in that speed range.

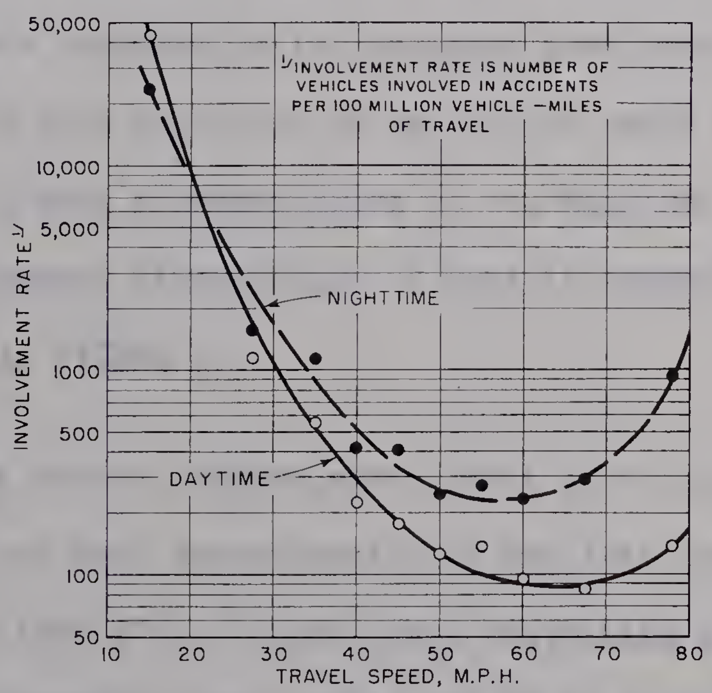


FIGURE 3.2 ACCIDENT INVOLVEMENT RATES BY TRAVEL SPEED

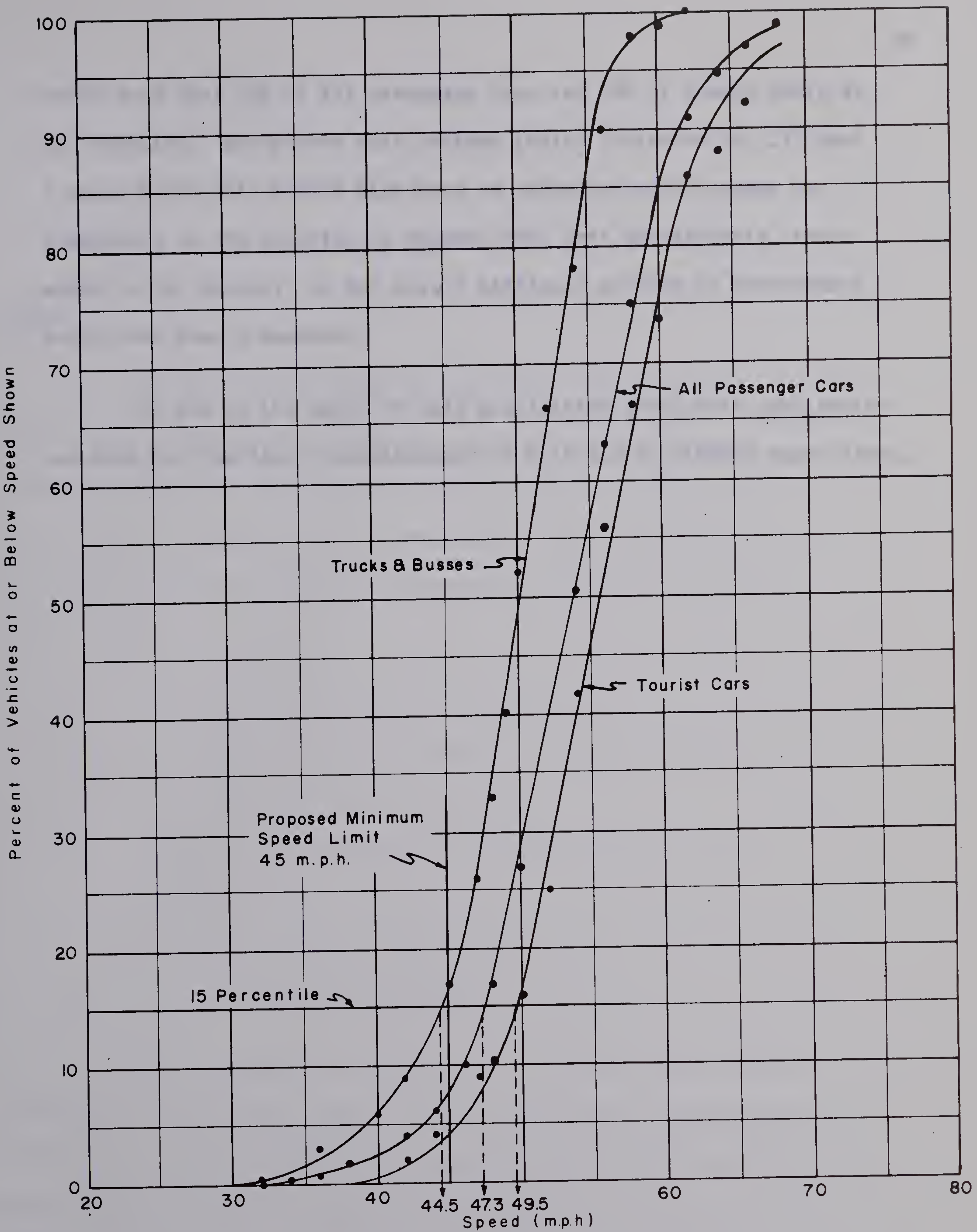
These findings illustrate the important influence that control of low speeds could exert on accident frequency. In selecting a highway both for test and control purposes it was necessary to look for a highway 1) for which accident statistics were readily available and 2) whose accident occurrence was frequent enough to give a real indication of differences over the comparatively short test period.

In order to insure ready access to accident files an attempt was made to have the accident reports filed by location of occurrence. However this was not accomplished until late 1964 so that a laborious search was necessary to locate the reports for the years 1963 and 1964.

RADAR STUDY

During the formative stages of this research radar spot speed measurements were recorded on the proposed test section. This study was necessary to give some idea of the proper speed at which to set the limit and to make a presentation to the Manitoba Highway Traffic Board. The frequency distribution of vehicle speeds from this study is illustrated in FIGURE 3.3.

From this data a minimum speed limit of 45 m.p.h. was recommended as the best approximation to the 15th percentile. The study indicates that 17% of trucks were travelling less than 45 m.p.h. as were 8% of passenger cars. While the 8% of passenger cars is a somewhat small portion of the total volume to deal with, it can be seen from FIGURE 3.3 that an increase of the minimum to 50 m.p.h.



CUMULATIVE FREQUENCY OF DAYTIME SPEEDS ON PROVINCIAL HIGHWAY №.1 FROM RADAR MEASUREMENTS JULY, 1962

Figure: 3·3

would mean that 30% of all passenger cars and 50% of trucks would be in violation. Experience with maximum limits indicates (4, 13) that a speed limit with a very high rate of violation would appear unreasonable to the majority of drivers and, that unreasonable limits would not be obeyed. In any case a difficult problem in enforcement would have been presented.

It was on the basis of this preliminary study that application was made for the legal establishment of a 45 m.p.h. minimum speed limit.

CHAPTER IV

TEST METHODS

GENERAL

The objective of this investigation was to determine the effectiveness of minimum speed limits on two lane rural highways. In order to make this assessment it was necessary to first attempt to understand the purpose intended when such a limit was imposed. Based on the information gained in preliminary studies the expected results might be:-

1. To increase the speed of slower vehicles.
2. To reduce the speed of vehicles relative to each other.
3. To decrease accident occurrence.
4. To aid in enforcement of the rules relating to slow moving traffic.
5. To reduce passing manoeuvres.
6. To increase highway capacity.

In order to assess the effectiveness of a minimum speed limit, in accomplishing the above possible results in a manner acceptable to the public and without placing undue restrictions on the use of the highway, a test procedure was devised as follows:-

1. A two lane highway section was chosen as a test road and a legally constituted minimum speed limit was imposed and enforced.

2. A highway with similar characteristics was chosen as a control section.

3. Before and after spot speed distributions were measured both during daylight and darkness on the test and control locations.

4. Travel times and overtaking were computed at both locations by license matching before and after.

5. Before and after accident occurrence was analyzed.

6. A sample of public opinion was obtained by means of roadside interviews.

7. Traffic volume changes were analyzed.

This test method provided the facility to make some assessment of all of the purported advantages of minimum speed limits.

TEST LIMITATIONS

The most serious limitation in the test was the requirement that the duration was limited to one year. An indication of accident trends will be available since approximately 60 accidents per year occur on

the test section. However, a longer record period would have been desirable to firmly establish the accident trend.

The test is somewhat restricted also by the fact that it was not possible to vary the numerical minimum speed limit.

LEGAL ARRANGEMENTS

Beginning in 1962 approaches were made to the Manitoba Provincial authorities for authorization to set up a test and control section of trunk highway for the purposes of this test. At that time the jurisdiction in these matters lay with the Minister of Public Works. The Highway Traffic Act was under review, however, and matters relating to speed limits were being transferred to the authority of the newly formed Highway Traffic and Co-ordination Board. At the time of revision the section of the Highway Traffic Act dealing with minimum speed limits was overlooked, and it wasn't until 1963 that the Traffic Board obtained jurisdiction under Section 70-5 of the Highway Traffic Act (25).

> "70-5 (1) No person shall drive a motor vehicle at such a slow speed as to impede or block the normal and reasonable flow of traffic, except when it is necessary to do so for safe operation or to comply with this Part.
>
> (2) The traffic board may make an order fixing, for any highway or portion of a highway designated in the order, the minimum speed permissible thereon.
>
> (2A) Upon making an order under subsection (2), the traffic board shall forthwith send a copy thereof to the traffic authority having jurisdiction over the highway to which the order applies.
>
> (2B) Where the traffic board makes an order under subsection (2), the traffic authority shall erect and maintain "Stop" signs,

"Yield signs, or traffic control signals, at the intersection of all other highways with the highway or portion thereof, to which the order applies, and shall erect and maintain at each end of the highway or the portion thereof to which the order applies and along the highway or portion thereof at intervals of not more that one mile, signs indicating the minimum rate of speed allowed thereon.

(3) Where the driver of a motor vehicle is driving at such a slow speed that he is impeding or blocking the normal and reasonable flow of traffic or is driving at a rate less than the minimum fixed under subsection (2), a peace officer may require him to increase his rate of speed or to remove the vehicle from the highway.

(4) No person shall drive a motor vehicle on a highway in respect of which an order has been made under subsection (2) and in respect of which traffic control devices have been erected and are maintained as required under subsection (2B) at a rate of speed less than the minimum speed fixed for that highway or portion thereof, unless

(a) he is impeded by other traffic travelling on the or by the condition of the highway or the weather; or

(b) he is decelerating in compliance with the instructions on a traffic control device erected on the highway; or

(c) he is decelerating for the purpose of turning from the highway or stopping in compliance with the provisions of this Act."

Permission was obtained from the Minister of Public Works in 1964 to make application to the Traffic Board for the installation of a minimum speed limit on the Trans-Canada Highway No. 1 for 33 miles between the Cities of Portage la Prairie and Winnipeg.

In considering the application and based on previous spot speed measurements shown in FIGURE 3.3, the Traffic Board considered 45 m.p.h. as the proper minimum limit. However, the maximum speed limit on the highway was 60 m.p.h. during the day and 50 m.p.h. at night. In order

to allow a reasonable speed range the Traffic Board adjusted the maximum limit to 60 m.p.h. day and night on the entire Trans-Canada Highway in Manitoba.

FIGURE 4.1 is a copy of the regulation handed down by the Traffic Board October 8, 1964 which finally created the minimum speed limit for this test. It was desirable to have the actual installation completed as soon as possible after the regulation passed but it was first necessary to collect advance speed information. Test sites were selected and minimum speed signs installed on the highway December 1, 1964.

RADAR SPOT SPEED MEASUREMENTS

The detailed measurement procedure set out in Appendix A was used to clock approximately 25,000 vehicles for this test.

The first speeds were measured on the test section in October 1964 before test stations were laid out. These preliminary readings were taken approximately every mile.

Radar stations were then set up at approximately five mile intervals along the test and control sections. This resulted in four stations (numbered 1 to 4) on the control section and six stations (numbered 6 to 11) on the test section. Radar stations 5 and 12 were located on the west and east end respectively of the alternate route. At station No. 7 separate readings were taken with the radar

November 7, 1964. THE MANITOBA GAZETTE Vol. 93, No. 45

MANITOBA REGULATION 87/64

Being

ORDER NO. 4 -64

of

The Highway Traffic and Co-ordination Board
made under
section 70-5(2) of The Highway Traffic Act
respecting the minimum speed permissible on
part of P.T.H. No. 1

(Filed November 3rd, 1964.)

1. On all that portion of the highway situated in The Rural Municipality of Portage la Prairie, The Rural Municipality of Cartier and The Rural Municipality of St. Francois Xavier commonly known as Provincial Trunk Highway No. 1 and also commonly known as the Trans-Canada Highway, beginning at a point where the east boundary of River Lot 133 of the Parish of Portage la Prairie crosses the highway and continuing in an easterly direction to a point where the east boundary of River Lot 200, Parish of St. Francois Xavier crosses the highway, the minimum speed permissible is fixed at forty-five miles per hour.

Dated at The City of Winnipeg, in Manitoba, this 2nd day of November, 1964.

Rae Henry Tallin,
Chairman,
THE HIGHWAY TRAFFIC AND
CO-ORDINATION BOARD.

MANITOBA
REGULATION 87 / 64

Figure: 4·1

equipment set up first on the south side facing east, and then on the south side facing west to determine whether this had any effect on results.

SAMPLE SIZE

Collection of data on spot speeds is statistically a sampling operation. This means that a portion of the total vehicle population is measured and the results are considered to be representative of the total population. The information becomes more accurate as the sample size increases. On the other hand costs increase as the sample size increases and an increase in sample size does not yield a proportional increase in accuracy of estimation (35).

Sampling is therefore a compromise between cost and accuracy. Studies at the University of Illinois (23) have led to the preparation of a set of curves, one of which is shown in FIGURE 4.2, based on the equation

$$N = \frac{v^2 S^2 (2 + u^2)}{2d^2}$$

where N = minimum sample size

v = normal deviate corresponding to the desired confidence level

s = standard deviation of the sample

u = normal deviate corresponding to the percentile being estimated

d = permitted error in the estimate

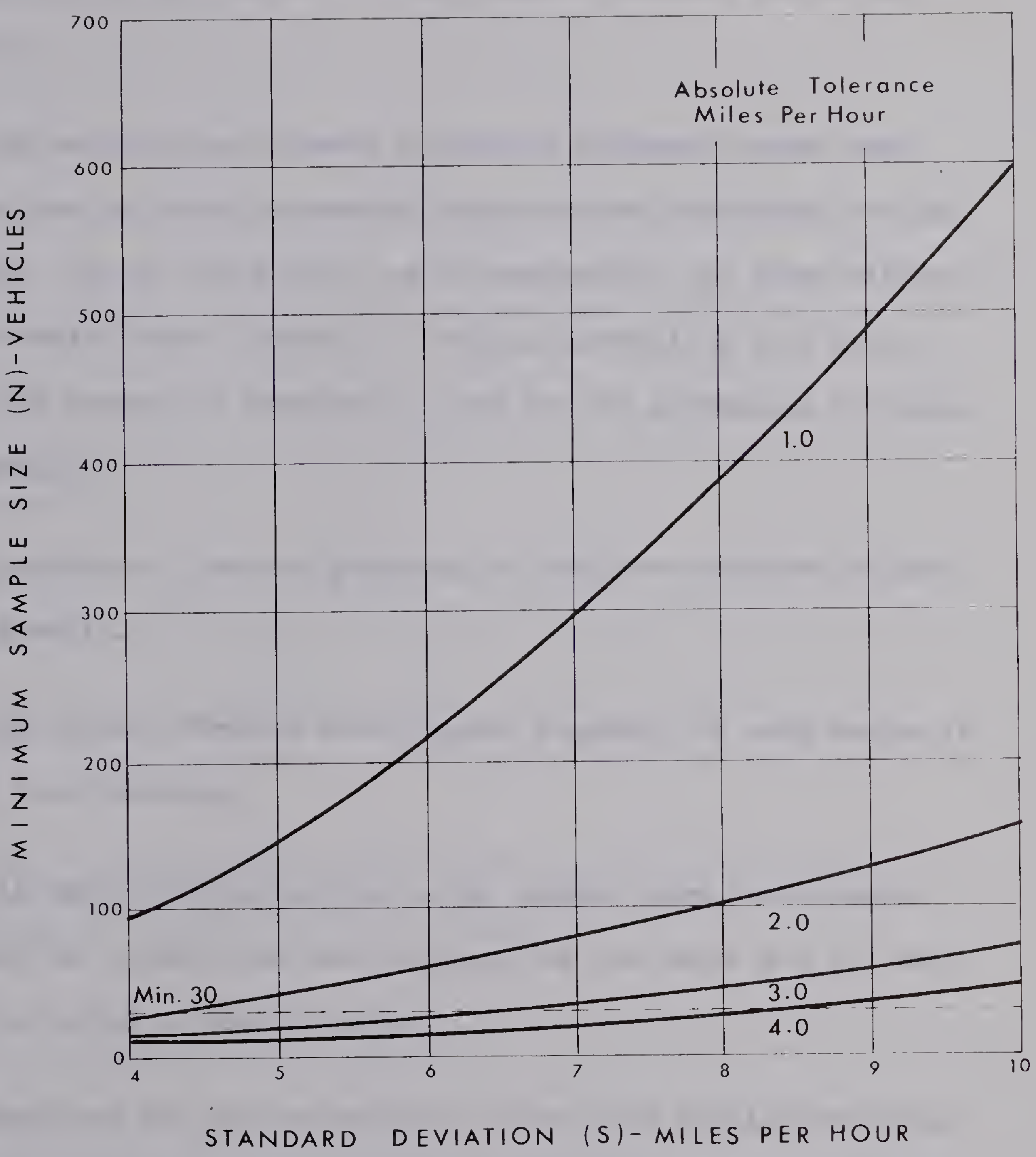
The sample standard deviation is the only variant directly affected by vehicular speeds. The standard deviation for this test, based on preliminary studies, was estimated to be 6.5 m.p.h. For a 1 m.p.h. permitted error in the 15th and 85th percentile value, and at 95% confidence level, the minimum sample size taken from FIGURE 4.2 is 250 vehicles. Accuracy at the 50th percentile would be somewhat greater. This size of sample was consistent with the time and resources available and was adopted as the minimum for each study.

Grouping each series of studies yielded sample sizes of 1000 vehicles for the control section and 1500 vehicles for the test section. These samples give better than 1 m.p.h. accuracy at the 5th percentile with a 99% confidence level.

A series of radar measurements was considered to consist of day and night studies, with the minimum sample of 250 vehicles at all stations on the test and control sections and day studies only on the alternate route.

The first series of radar measurements was completed in November 1964 before the minimum limit was established. After the minimum was installed a partial series was taken in December 1964, but due to the effects of the Christmas season the complete series was not finished until March 1965.

Approximately one year after the limit had been in effect,



NOTE:
Percentile = 15% and 85%
Desired Confidence Level = 95%

MINIMUM SAMPLE SIZE
VS.
STANDARD DEVIATION

Figure: 4·2

during October and November of 1965, another complete series was conducted.

For each series of tests cumulative frequency curves were drawn and the following parameters were recorded separately for day and night; the 85 percentile, the 15 percentile, the speed differential, the median speed, percent of vehicles travelling less than 45 m.p.h., the percent of vehicles in pace and the percentage of trucks in the sample.

In addition, certain groupings of data were combined to give overall results.

All control stations were grouped together for each series as were all test stations.

All before studies and all after studies were also grouped separately for control and test section, day and night and for daytime tests on the alternate route.

Data from the two end stations of the test section (stations 6 and 11) were also compared to that of mid-stations to see if there were any differences in speed pattern due to the initial impact of the signing.

Since conditions of roadway, weather and traffic volumes varied only slightly from station to station these groupings appear valid.

TRAVEL TIME MEASUREMENTS

Travel time measurements were carried out as outlined in Appendix A. Separate studies were performed on both control and test sections before and after the establishment of the minimum speed limit.

The expense of this part of the test was considerable as it involved the use of four men and two vehicles. The duration of the data gathering period had to be confined to four days. One full day was spent on both control section and test section both before and after. Since the control section had a slightly lesser volume and was farther from the base of operations in Winnipeg, requiring more travelling time, the sample sizes were smaller than for the test section.

From the average speeds calculated the speed distribution curves were plotted and mean speeds computed.

INDEX OF OVERTAKING

During the compiling of travel time data it was noted that the listings gave the order that vehicles entered the test area and the order in which they left the other end. By comparing these arrangements of vehicles it was possible to count the number of instances of overtaking that had occurred amongst through vehicles. For example, a vehicle arriving ahead of four vehicles which had entered in advance of it is said to be involved in 4 overtaking

occurrences. Totalling the occurrences for all vehicles in the test gives the total number of passing occurrences q.

If $v =$ total number of vehicles matched

$d =$ total length of the test course in miles

then $\frac{q}{vd} =$ number of passing occurrences per vehicle mile

If $m =$ total length of time of observation in minutes

then $\frac{v}{m} =$ gives the density of through traffic in vehicles per minute

and $\dfrac{\frac{q}{vd}}{\frac{v}{m}} = \dfrac{qm}{v^2 d}$ is the number of overtaking occurences per vehicle mile per unit of density

The index of overtaking Ov is defined as -

$$Ov = c\left(\frac{qm}{v^2 d}\right)$$

where c is a constant for each test course depending on intermediate access, roadside friction and composition of traffic.

The index of overtaking was calculated for the test and control sections as a measure of change in passing occurrence.

ACCIDENT ANALYSIS

In order to compile the accident record for this test, access was obtained to the actual accident reports. For the year 1965 the reports were filed by location. For 1963 and 1964, however, the reports were mixed into a general police detachment file. This

required the separation of the pertinent records from over 2000 reports in each year.

The information from the accident reports was summarized on a data sheet as illustrated in FIGURE 4.3. The information was then sorted by control and test section and by year of occurrence.

The following information was then listed:-

1. Number of accidents.
2. Number of vehicles involved.
3. Number of severe accidents (involving death or injury).
4. Number of people injured and killed.
5. Number of accidents during daylight.
6. Number of accidents at night.
7. Number of commercial vehicles involved.
8. Estimated property damage.
9. Number of accidents involving passing.

From the above data the accident rate per million vehicle miles and the severity ratio were calculated. The severity ratio is the ratio of the number of severe accidents to the total number of accidents usually expressed as a percentage. It signifies the percentage of accidents in which there occurred death and injury.

ROADSIDE INTERVIEWS

To obtain a sample of public opinion regarding minimum speed

Date: 25-8-65 Time: 11:15 AM
Location: McGREGOR
No. of Vehicles: 2 D.
Fatal: P. I. 3 P. D.
Am't Damage: $2300.
Summary: 5001010 9. E-B car pulled onto right shoulder & then made a left turn & was hit by a following E-B car
CH

Date: 17-4-65 Time: 9:30 PM
Location: 1 E AUSTIN
No. of Vehicles: 1 N.
Fatal: P.I. 3 P.D.
Am't Damage: $4000.
Summary:
5001010·16
E-B. car blinded by lights & took to ditch.

Date: 17-8-65 Time: 1.00 AM
Location: 7-5 E. McGREGOR
No. of Vehicles: 1
Fatal: P.I. P. D. ✓ N.
Am't Damage: $150
Summary:
5001010 1.5 W-B car claims to have been forced into right ditch by E-B car in his lane, passing.

Date: 17-4-65 Time: 10:30 PM.
Location: Austin
No. of Vehicles: 3
Fatal: P.I. 1 P.D. N.
Am't Damage: $ 875.
Summary:
3 W-B cars. #2 & #3 began to pass at same time as #1 turned left.

Date: 22-7-65 Time: 5:55 AM
Location: 1 W. McGregor
No. of Vehicles: 2
Fatal: P. I. P. D.
Am't Damage: $200.
Summary:
5001010 15. E-B car passing an E-B ~~co~~ semi in fog and confronted by a W-B car - Sideswipe
CH

Date: 21-1-65 Time: 1:30 PM.
Location: 2 E. austin
No. of Vehicles: 1
Fatal: P.I. P.D. ✓
Am't Damage: $250.
Summary:
5001010 13. E-B car slid out of control into ditch.

Date: 5-6-65 Time: 5:30 PM
Location: McGregor
No. of Vehicles: 2 D.
Fatal: P. I. P. D.
Am't Damage: $500
Summary:
5001010 9 E-B car hit a S-B car that entered hwy illegally from side road.

Date: 21-12-64 Time: 6:30 AM.
Location: 5 E. austin
No. of Vehicles: 2
Fatal: P.I. P.D.
Am't Damage: $ 1100.
Summary:
5001010 12.5 W-B car & E-B semi both too close to centre in a snowstorm - Sideswipe

ACCIDENT RECORD
DATA SHEET

Figure: 4·3

limits a roadside interview was undertaken using the procedure described in Appendix A.

The interviews were confined to two days, November 5, 1965 and December 7, 1965. This limitation was necessary because of the difficulties in arranging for police officers, a five man interview team and the sign erection crew to be available at the same time. Since the start of cold weather also rendered further interviewing impractical, the proposed interviews on the control section were not proceeded with.

On the first interview day five questions were asked:-

1. What is your destination?
2. What are the speed limits on this highway?
3. Did you increase your speed because of the minimum speed limit?
4. Do you think minimum speed limits are a good idea?
5. Do you think that the 45 m.p.h. minimum on this road is a proper speed limit?

Before conducting the second days' interviews questions 4 and 5 were altered as follows; because it was thought they might be leading the interviewed person to making it easy for him to give a "yes" answer.

4. What do you think of minimum speed limits?
5. If you were setting the minimum speed on a road such as this at what speed would you set it?

Question 1 in the series was not pertinent to this study but was included so that the subject would be more relaxed for the questions which followed.

CHAPTER V

TEST LOCATIONS

THE TEST SECTION

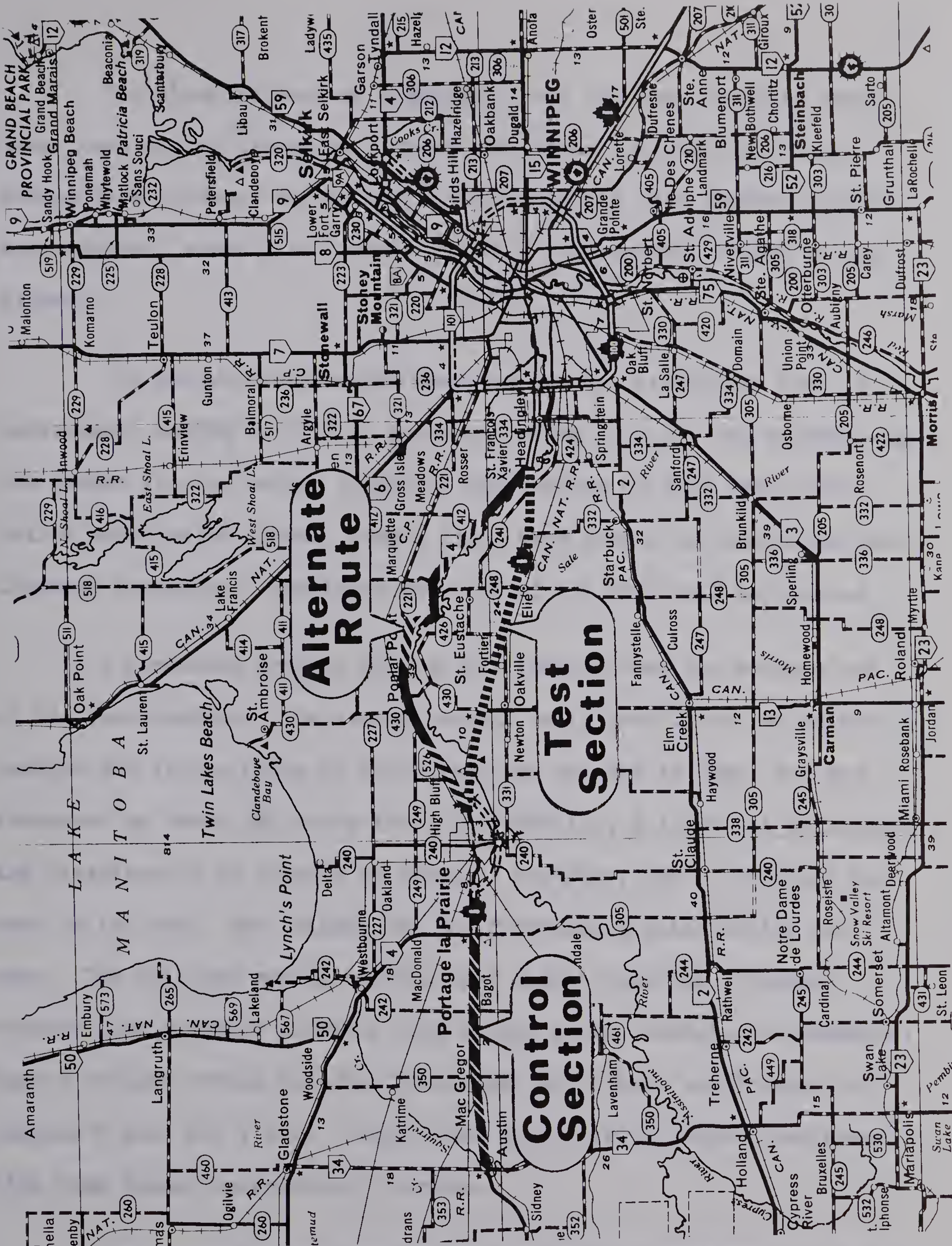
FIGURE 5.1 shows the geographic location of the test section with the alternate route No. 4 running parallel and to the north.

The thirty-three mile test section was through extremely flat terrain in the farmland of southern Manitoba. There were few trees adjacent to the road resulting in frequent bothersome crosswinds. There were few utility poles or other fixed objects near the highway which a driver could use as speed reference. A ten mile section of roadside delineators from a previous research project were still in existence.

The test section had only two curves both under 3°. The longest tangent section was twenty-one miles in length. Visibility was excellent at all points on the section.

The highway had two 12 foot travel lanes and 10 foot shoulders with 4 to 1 side slopes. Side ditches were wide bottomed and well drained.

There were two main bridges on this section both of which cross the Assiniboine River. Bridge widths were 30 feet and lengths were 350 and 450 feet.



TEST SECTION
CONTROL SECTION
AND
ALTERNATE ROUTE
LOCATIONS

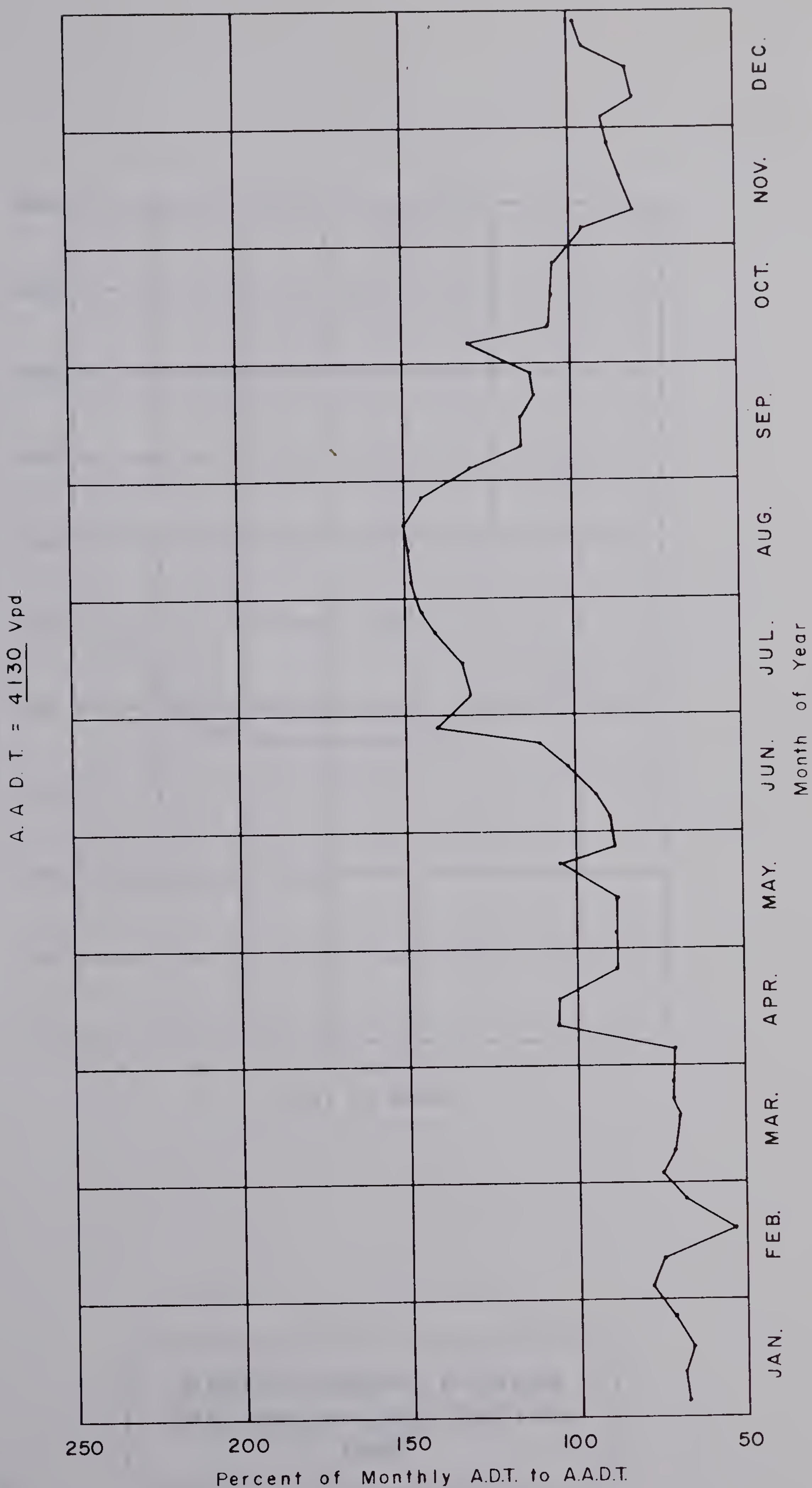
Figure: 5·1

The intersections of highways 13 and 248 were the only important junctions on the route. There were three intersections with market type roadways and access to the municipal road system occurred approximately every mile. There was also some private access to the highway.

The roadway surface was concrete and was relatively free of unevenness, having a C.G.R.A. pavement rating of 8.6. The roadway edge was marked for the entire length of the section on both sides with yellow solid paint lines. Centre lines were marked in accordance with Canadian standards. Shoulders were gravel and were well maintained.

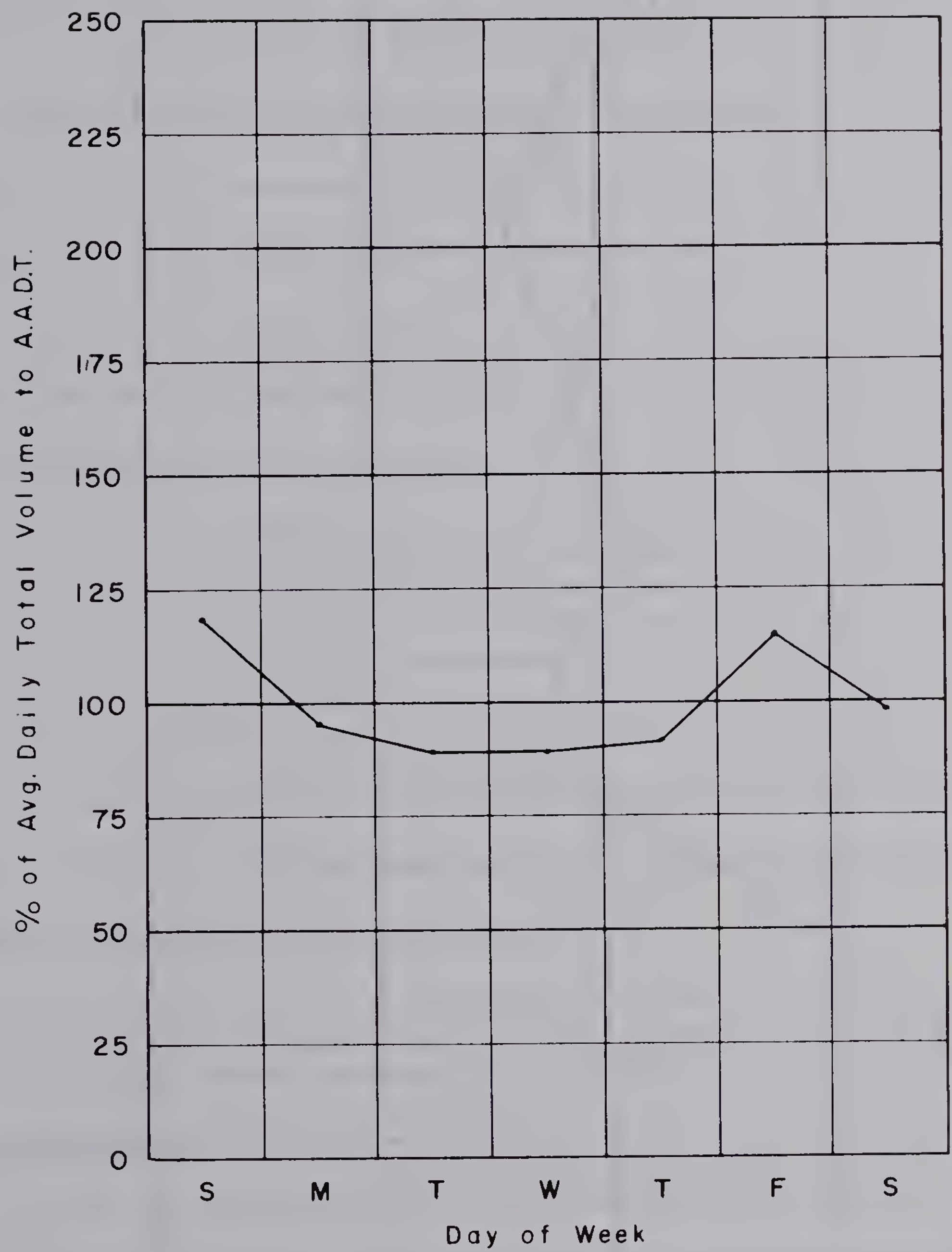
A permanent traffic counter was located near the western end of the test section. The average annual daily traffic on the entire section was in the range of 4,000 vehicles per day in 1965, and had increased by about 12% since 1963. FIGURES 5.2, 5.3 and 5.4 illustrate the distribution of volumes by month of the year, day of the week and hour of the day. The volumes did not fluctuate greatly during the year. The fall and spring volumes were almost constant. Weekday volumes also remained constant with slight peaks occurring on weekends. Hourly volumes during the day fluctuated very little but dropped off between 9 p.m. and 7 a.m. Traffic was classified as mainly business with some summer recreational increase.

In summary the test section was generally considered to be a flat uninteresting, even, boring highway with little variation in scenery or curvature. Traffic was heavy for a two lane rural highway



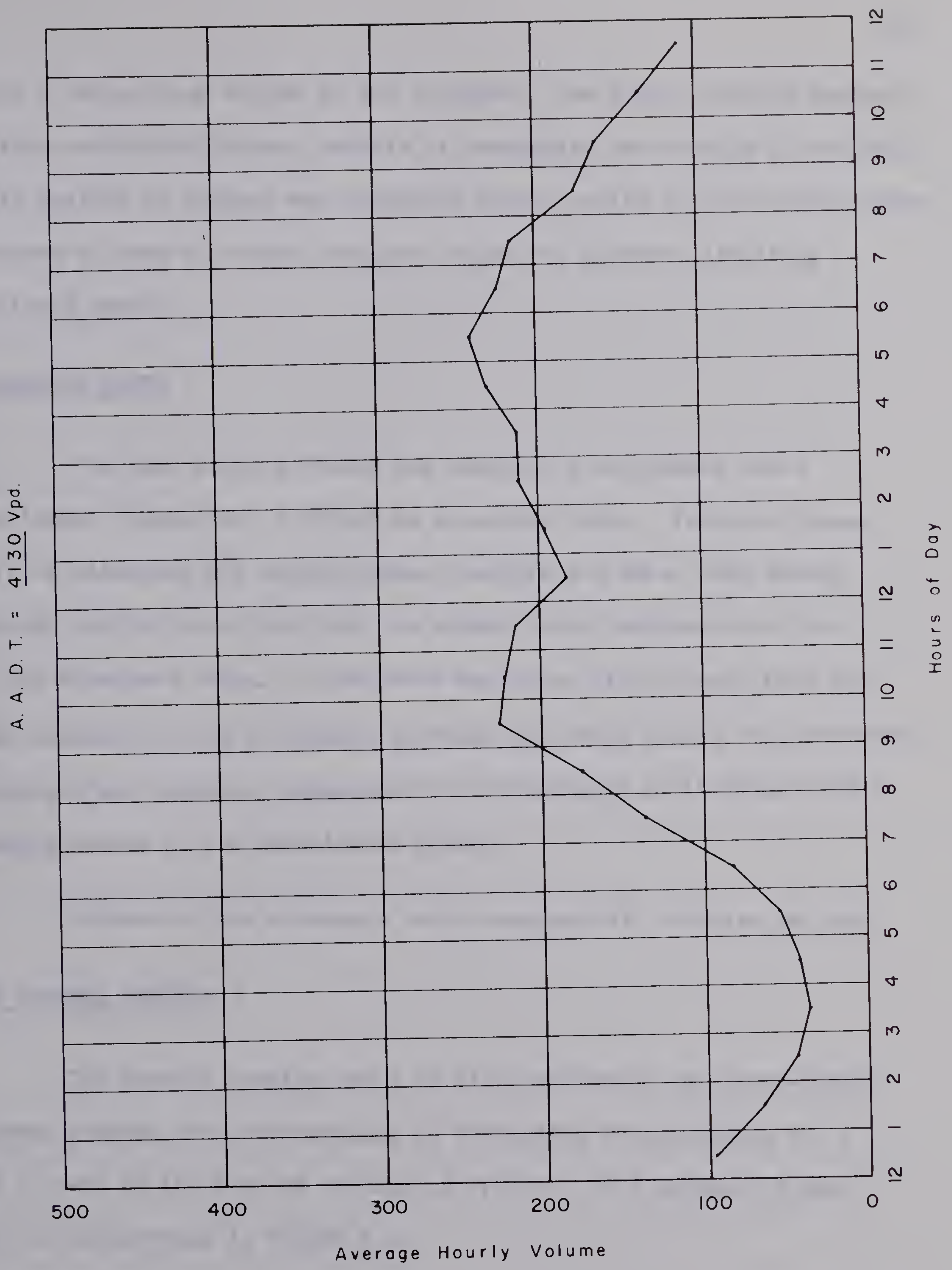
ANNUAL TRAFFIC PATTERN
EAST END OF TEST SECTION
1965

Figure : 5·2



WEEKLY TRAFFIC PATTERN
EAST END OF TEST SECTION
1965

Figure: 5·3



AVERAGE WEEKDAY

HOURLY TRAFFIC PATTERN

EAST END OF TEST SECTION

1965

Figure: 5·4

with a design hour volume of 600 vehicles. The Royal Canadian Mounted Police maintained highway patrols at Headingley and Portage la Prairie. This portion of highway was popularly known locally as the "death strip" because of several severe accidents which had occurred involving multiple deaths.

ALTERNATE ROUTE

The test section chosen was peculiarly acceptable since Provincial Highway No. 4 formed an alternate route. Vehicles incapable of attaining the minimum speed, convoys and other slow moving through traffic were thus able to attain their destination by use of the alternate route. This route was seven miles longer than the test section and had an asphalt surfaced two lanes with 3 foot shoulders. Alignment was somewhat substandard but picturesque as it followed the winding course of the Assiniboine River.

Volumes on the alternate route averaged 800 vehicles per day.

THE CONTROL SECTION

The control section was a 22 mile portion of the Trans-Canada Highway between the intersections of Provincial Trunk Highway No. 4 and 34 west of the City of Portage la Prairie. Its geographic position is illustrated in FIGURE 5.1.

The terrain was flat with all grades less than 3% but the landscape was slightly more treed than the test section. Roadside culture was mainly farming and the highway skirted two small villages.

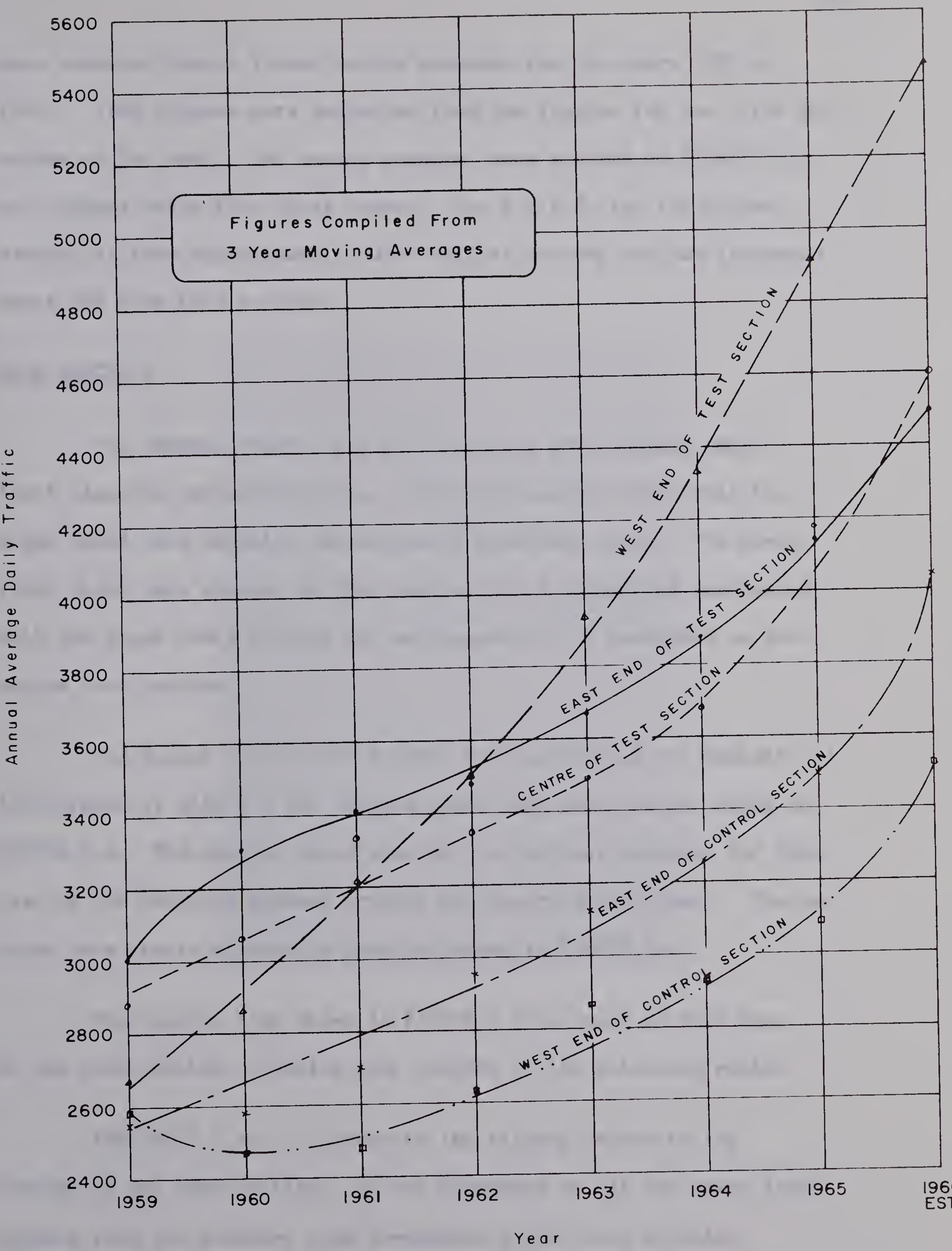
There were four curves on the control section one of which was 4°, two 3.5° and the other less than 3°. There was a long 13 mile tangent section similar to that on the test section.

The cross section of roadway side slopes and ditches was the same as on the test section. Two provincial roads intersected the highway in the control section and road allowance access occurred every mile. There was one level railroad crossing with automatic flashing light protection.

Roadway surface was asphalt and in this respect is different from the test section. A C.G.R.A. pavement rating survey made by the Manitoba Highways Department consisted of the individual opinions of five separate observers. The rating was on the basis of 10.0 being perfect and 6.0 being tolerable. The control section rated 8.1 while the test section rated 8.6 for 1964. This indicated no significant difference in the excellent riding qualities of these roadways.

Standard roadway markings were maintained on the control section. Pavement edge lines were not painted on this portion of highway.

There was no permanent counting station on the control section. Permanent counts taken in previous years indicated that the distribution of traffic over the year was very similar to the permanent station's on the test section and on Highway No. 4 near MacDonald. Short counts of two days duration once a year were taken on the control section and expanded by reference to the permanent counters. These expanded counts



TRAFFIC VOLUME TRENDS

Figure : 5:5

were combined into a 3 year moving averages for the years 1959 to 1966. 1966 volumes were estimated from the figures for the first six months of the year. The moving averages were plotted in FIGURE 5.5 and volumes taken from these curves. The A.A.D.T. for the control section is thus approximately 3000 vehicles per day and has increased about 10% from 1963 to 1965.

SIGN ERECTION

The Highway Traffic Act (25) required that minimum speed limit signs be posted every mile. This was taken to mean that the signs could face opposite directions at alternate miles. The speed limit signs were erected in this way so that a driver was confronted with the signs every 2 miles and was exposed to 16 reminders on the entire test section.

The Manual of "Uniform Traffic Control Devices for Canada" (5) illustrates as sign R-3 the maximum speed sign shown at the right of FIGURE 5.6. The minimum speed sign on the left was approved for this test by the Manitoba Highway Traffic and Co-ordination Board. The two signs were always erected in pairs as shown in FIGURE 5.6.

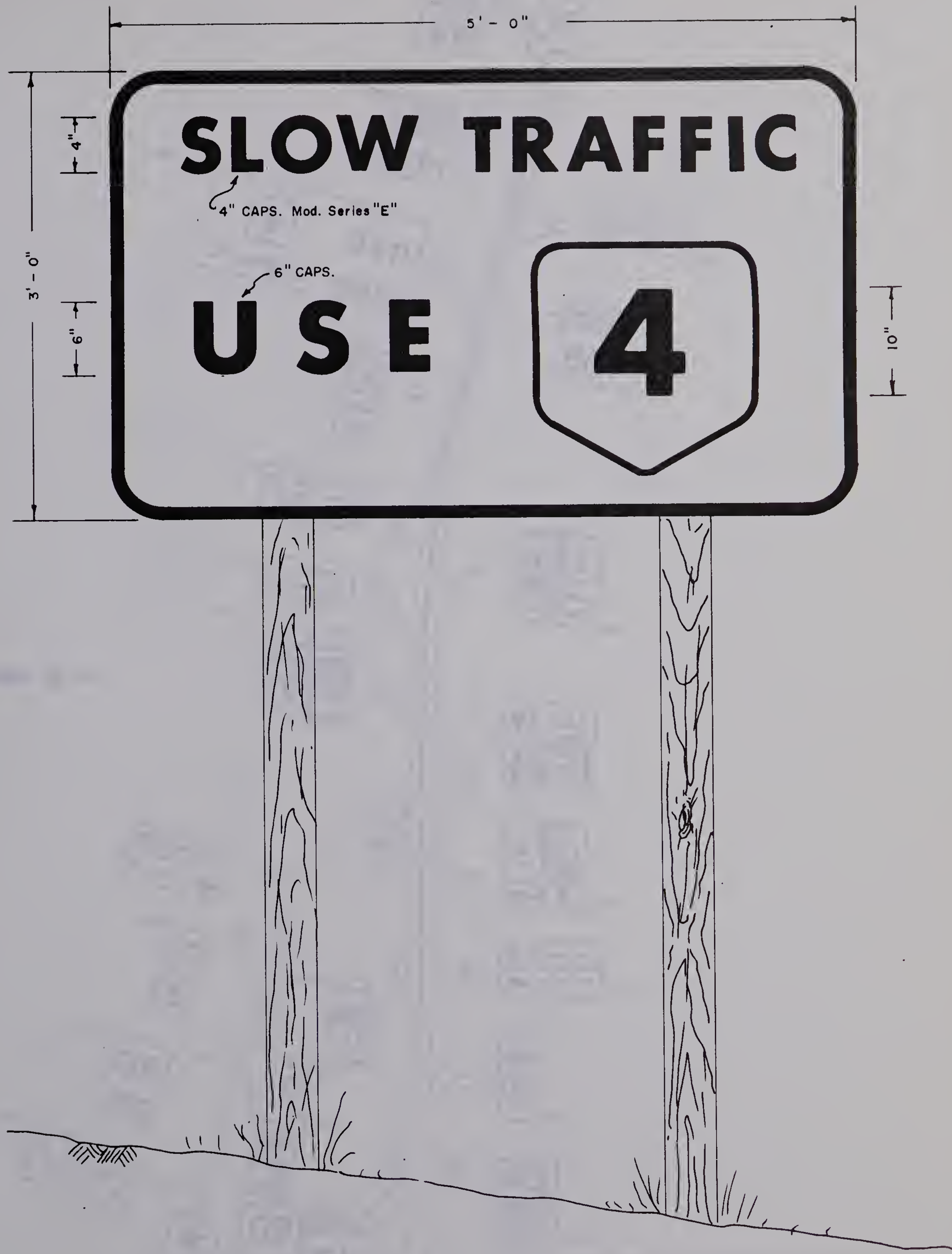
The special sign shown in FIGURE 5.7 was used at both ends of the test section to advise slow traffic of the alternate route.

FIGURES 5.8 and 5.9 indicate the signing layout at the termini of the test section. It was necessary to fit the speed limit signing into the standard sign arrangements that were existing.

Sign erection was completed on December 1, 1964.

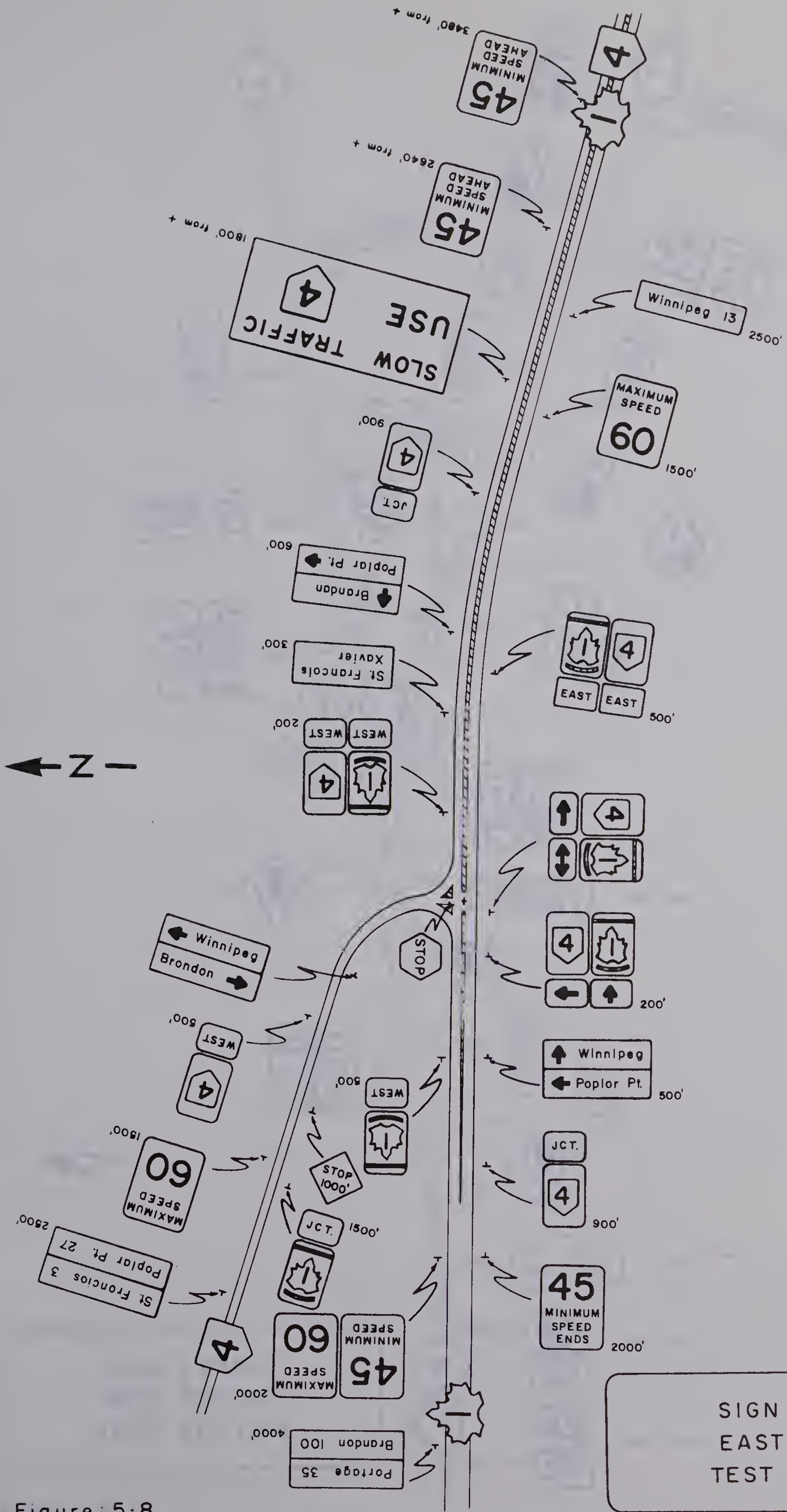
Figure: 5·6

SPEED LIMIT SIGNS



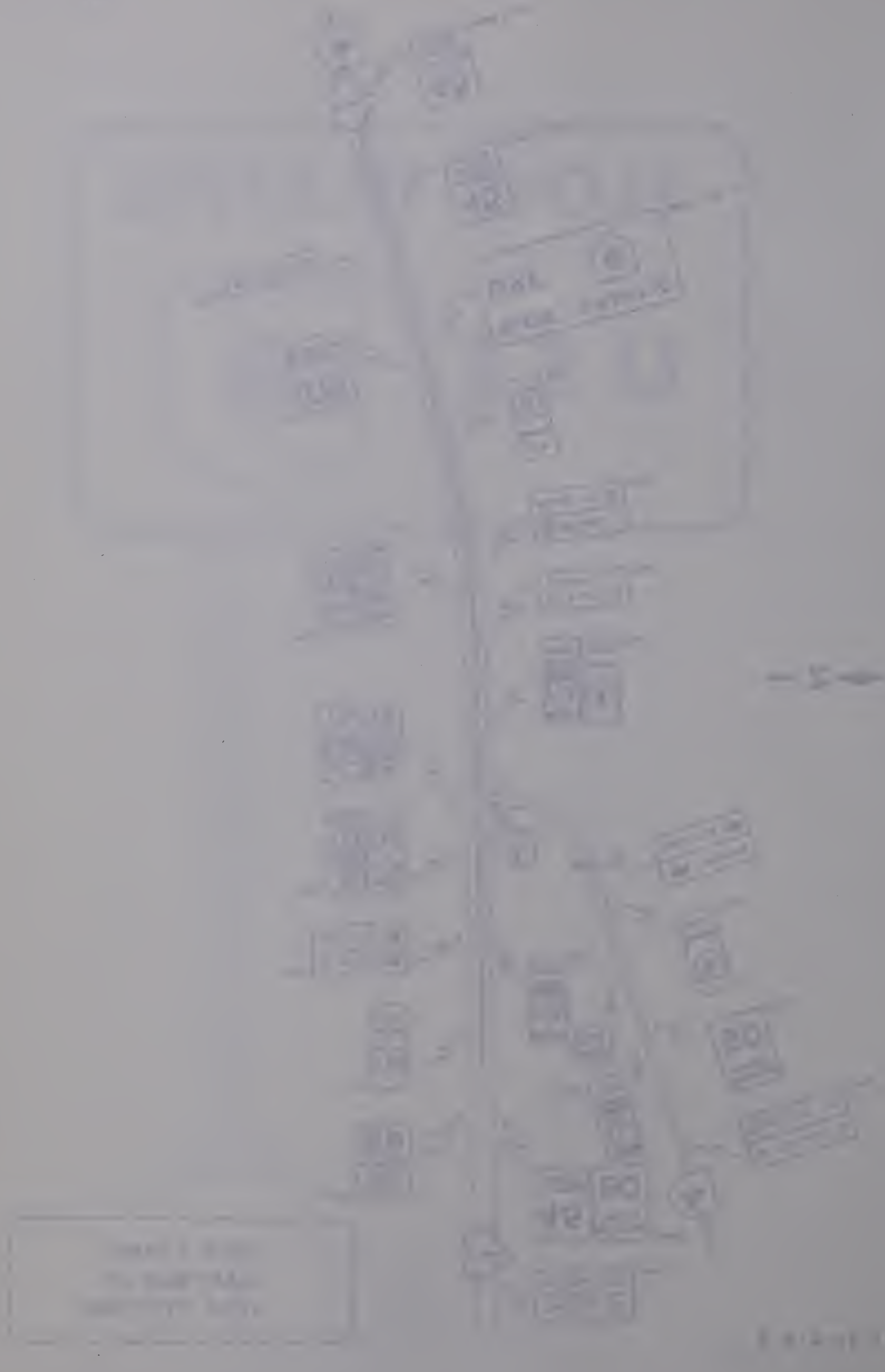
SIGN ADVISING
USE
OF ALTERNATE ROUTE

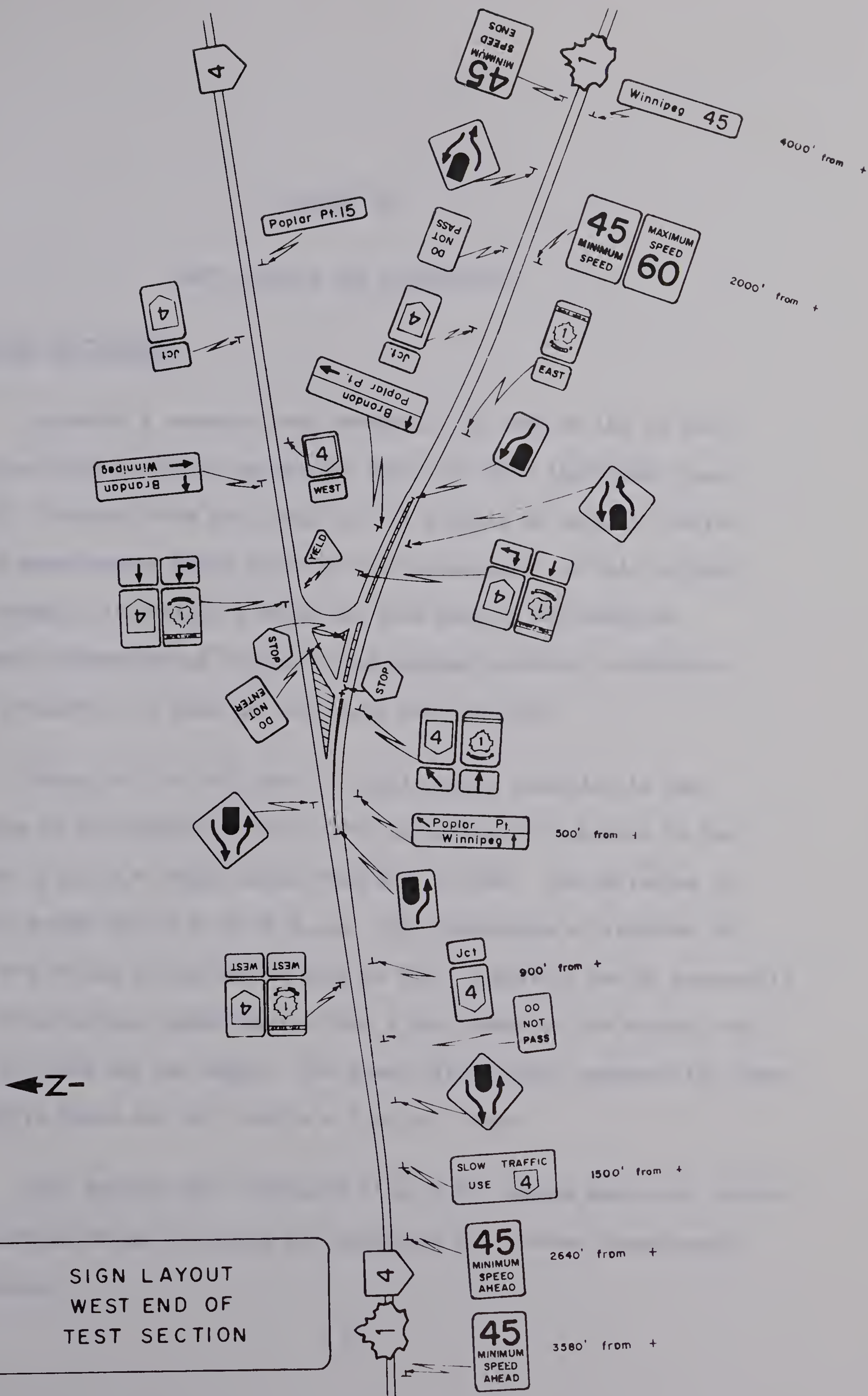
Figure : 5·7



SIGN LAYOUT
EAST END OF
TEST SECTION

Figure: 5·8





SIGN LAYOUT
WEST END OF
TEST SECTION

Figure : 5·9

CHAPTER VI

TEST RESULTS AND DISCUSSION

DAYTIME SPOT SPEEDS

Appendix B contains data summaries for each of the 12 test stations with important parameters shown for each individual test study. Included with this data are the results of several similar speed measurements taken prior to the commencement of this project. For example, at station 8 which had been used by the Manitoba Highways Department as a speed trend gauging location, statistics were available for both day and night back to 1962.

Tables B-I to B-IV show a considerable variation in test results on the control section. The percentage of vehicles in the "below 45 m.p.h." range varied from 4.5% to 36%. The variation in median speeds was 47.5 to 56 m.p.h. The percentage of vehicles in pace was as low as 54% and as high as 75%. Similarly the 85 percentile and 15 percentile speeds varied over a wide range on the control section for both day and night. The speed differential appeared the least sensitive value and fell within a 6 m.p.h. range.

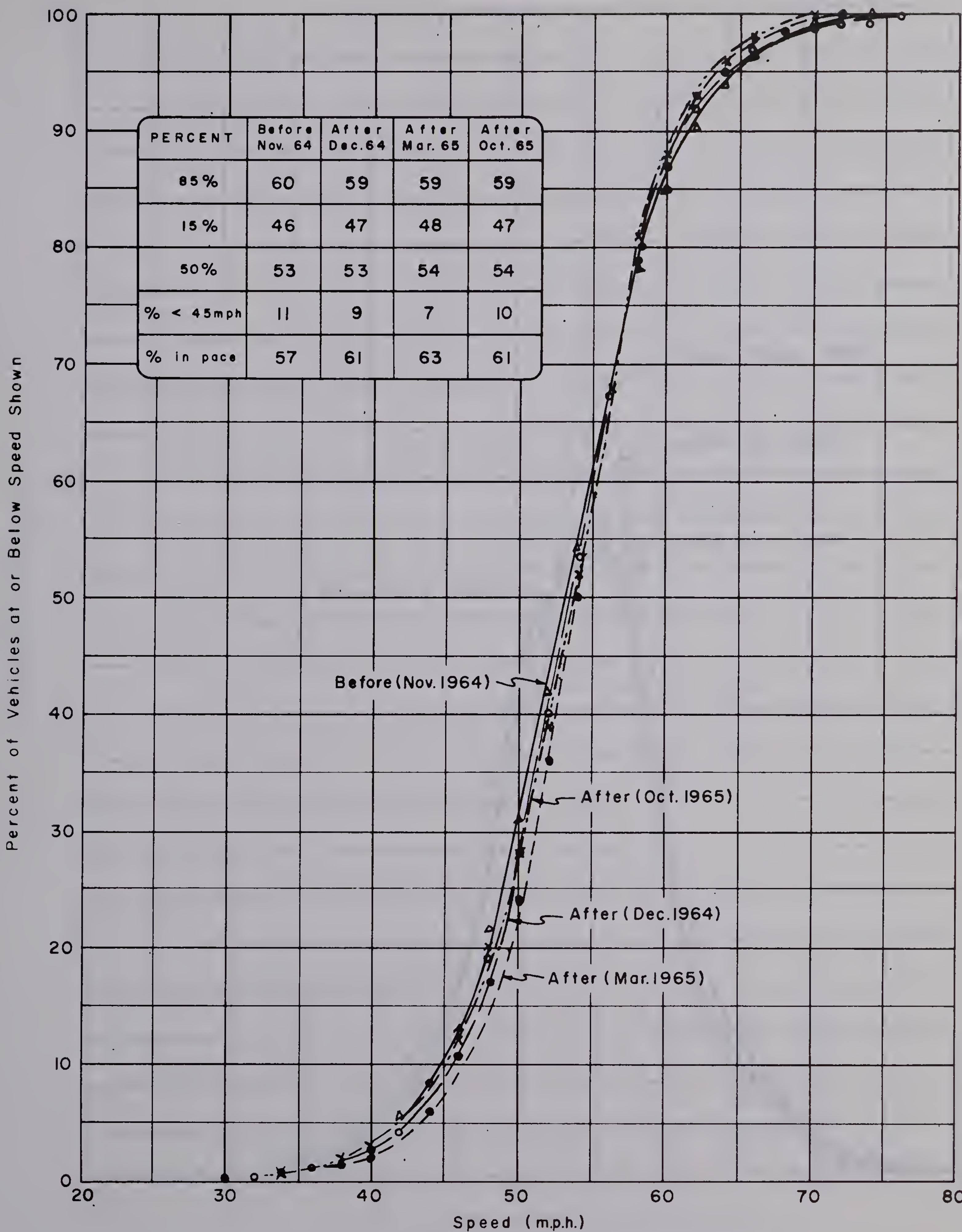
Test section data (Tables B-VI to B-XI) showed much more consistent daytime values but those for nighttime also showed considerable variation.

A comparison of the two sets of readings recorded at Station 7 with the radar antenna aimed in opposite directions indicated that this did not have a significant effect on the accuracy of results. In the November 1964 readings the median speed varied by 4.5 m.p.h. but, in general, was within 2 m.p.h. for the same study series. Averaging the median speeds for all series gave a value of 51.3 m.p.h. for antenna facing east and 52.0 m.p.h. facing west.

Because the mass of data caused difficulty in making an analysis station by station, and particularly in view of the considerable variation in results, it was desirable to combine these readings by grouping stations 1 to 4 on the control section and stations 6 to 11 on the test section. This was done for three individual night series of tests and four series during daylight. The resulting cumulative frequency curves and histograms are presented in FIGURES 6.1 to 6.8.

FIGURES 6.1 and 6.2 show a marked similarity in the distribution of daytime speeds for all four series of tests. The percentile speeds did not vary more than 2 m.p.h. The histograms were all of similar shape and the modal speeds were equal for all four curves. This indicated no change in speed patterns on the test section from before the minimum speed to immediately after, to four months after, or to a full year after installation.

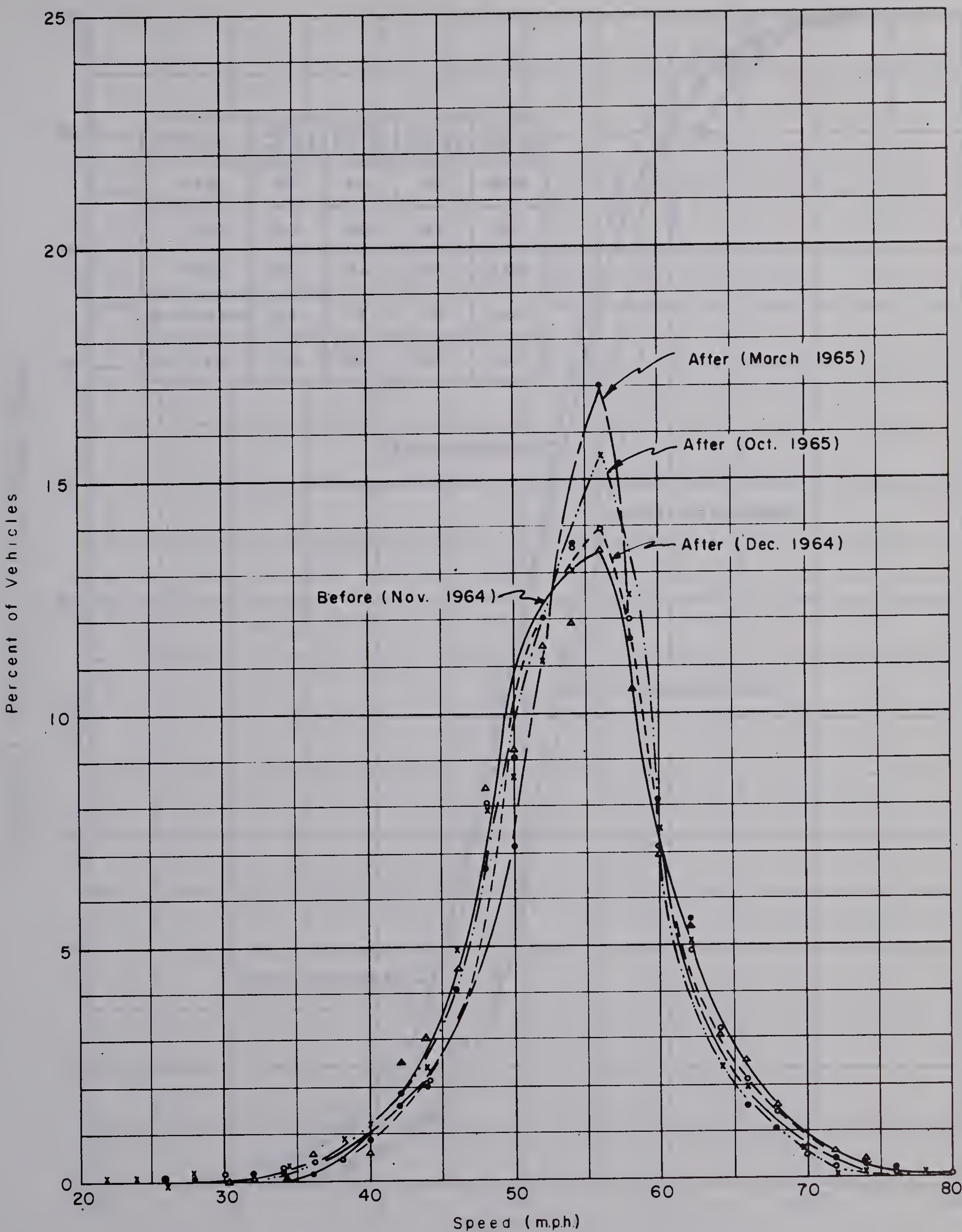
FIGURES 6.3 and 6.4 indicate daytime speed distribution on the control section for the same four test series. A different pattern was evident here with immediate "after" speeds 4 to 5 m.p.h. higher.



PERCENT	Before Nov. 64	After Dec. 64	After Mar. 65	After Oct. 65
85%	60	59	59	59
15%	46	47	48	47
50%	53	53	54	54
% < 45mph	11	9	7	10
% in pace	57	61	63	61

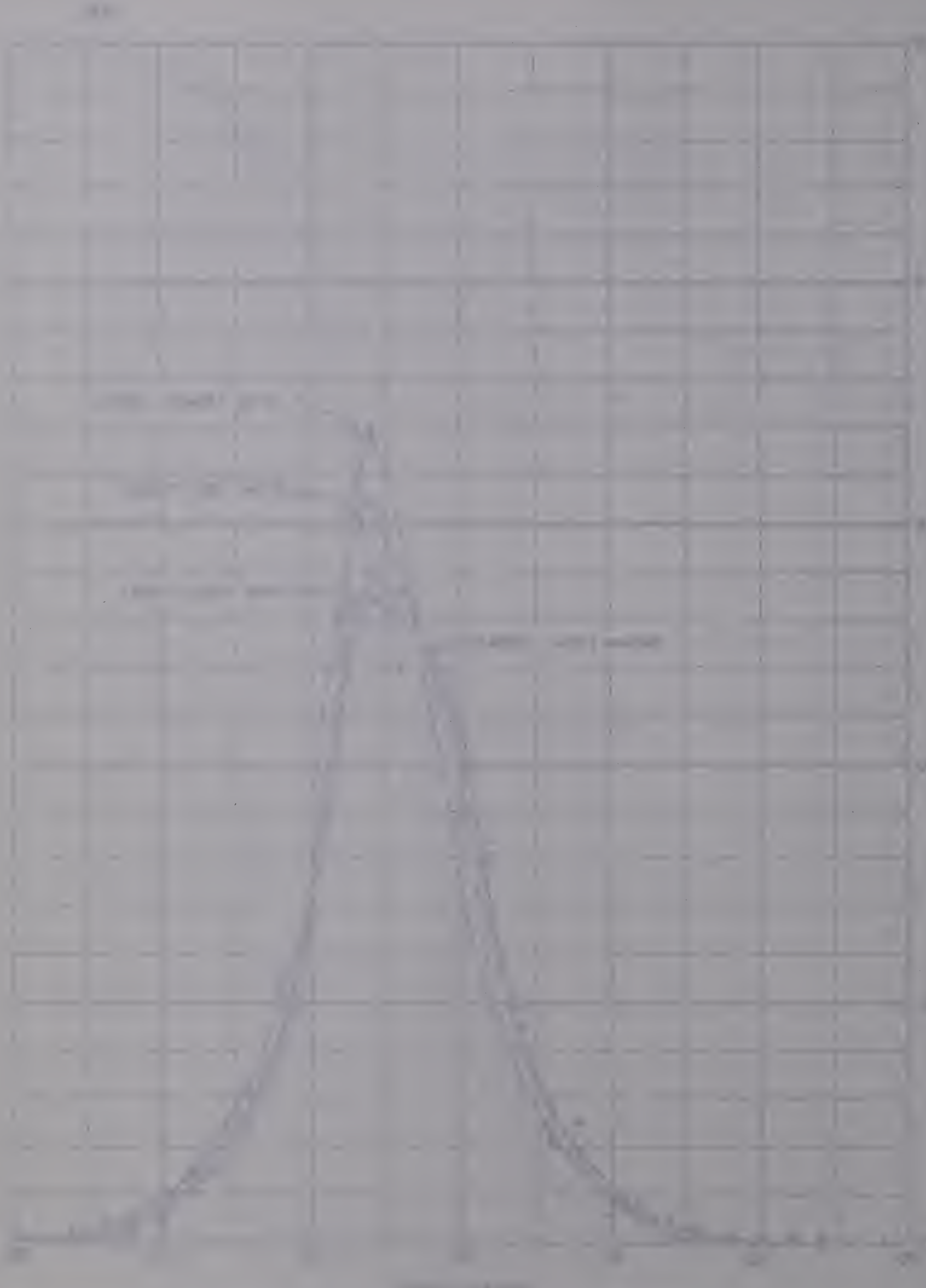
CUMULATIVE FREQUENCY
OF DAYTIME SPEEDS ON
TEST SECTION
FROM
RADAR MEASUREMENTS

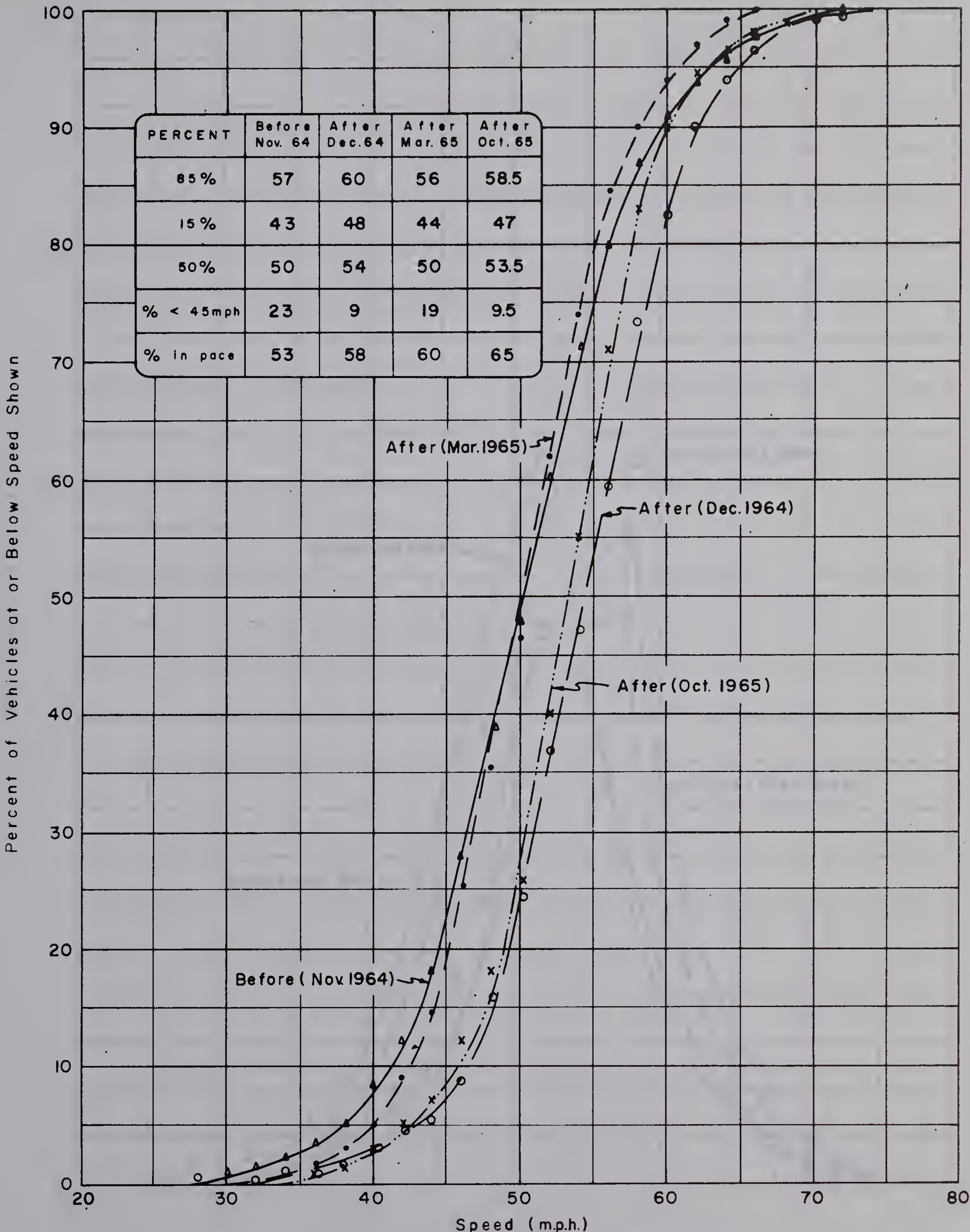
Figure: 6·1



HISTOGRAM
OF DAYTIME SPEEDS ON
TEST SECTION
FROM
RADAR MEASUREMENTS

Figure: 6·2

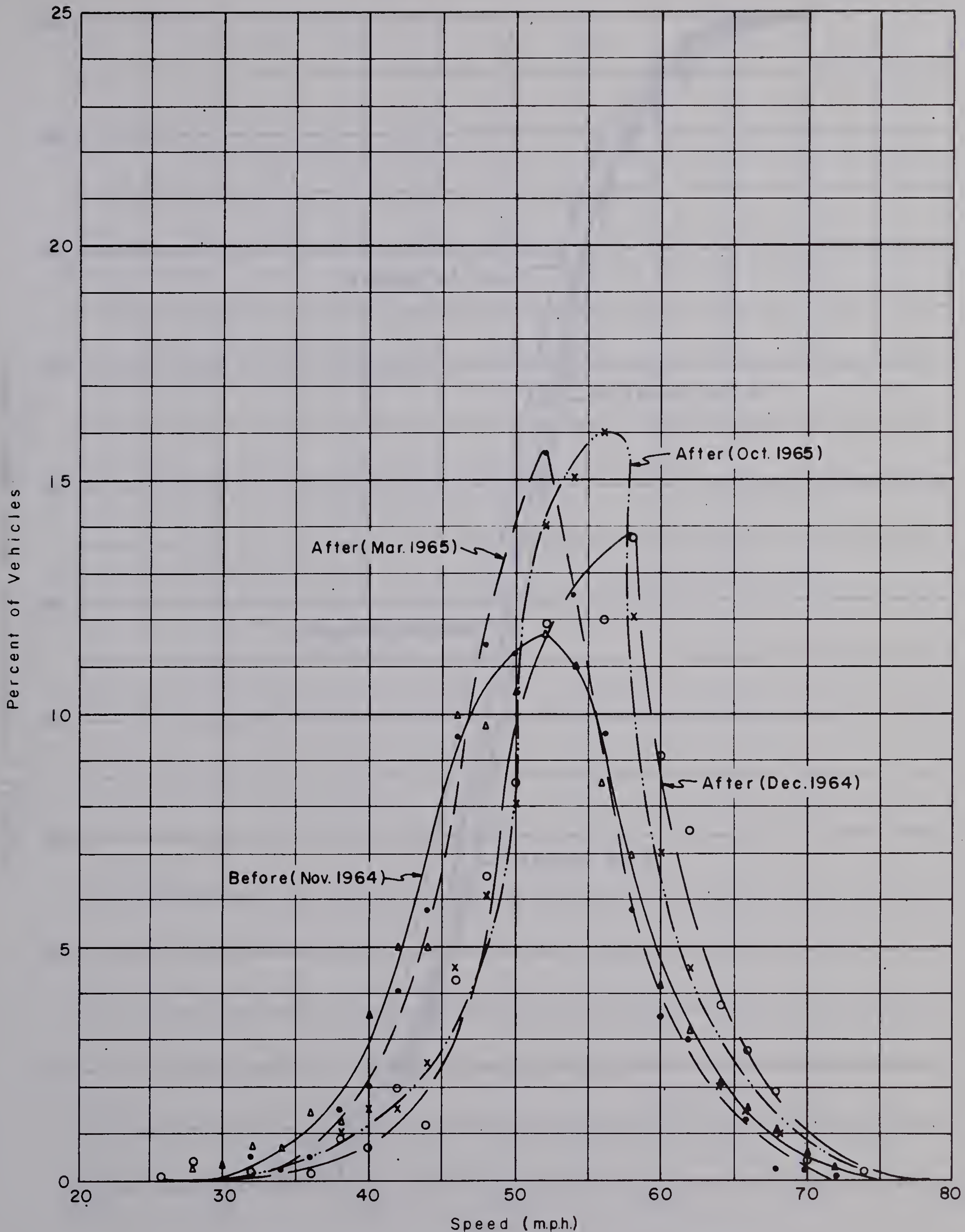




PERCENT	Before Nov. 64	After Dec.64	After Mar. 65	After Oct. 65
85%	57	60	56	58.5
15%	43	48	44	47
50%	50	54	50	53.5
% < 45mph	23	9	19	9.5
% in pace	53	58	60	65

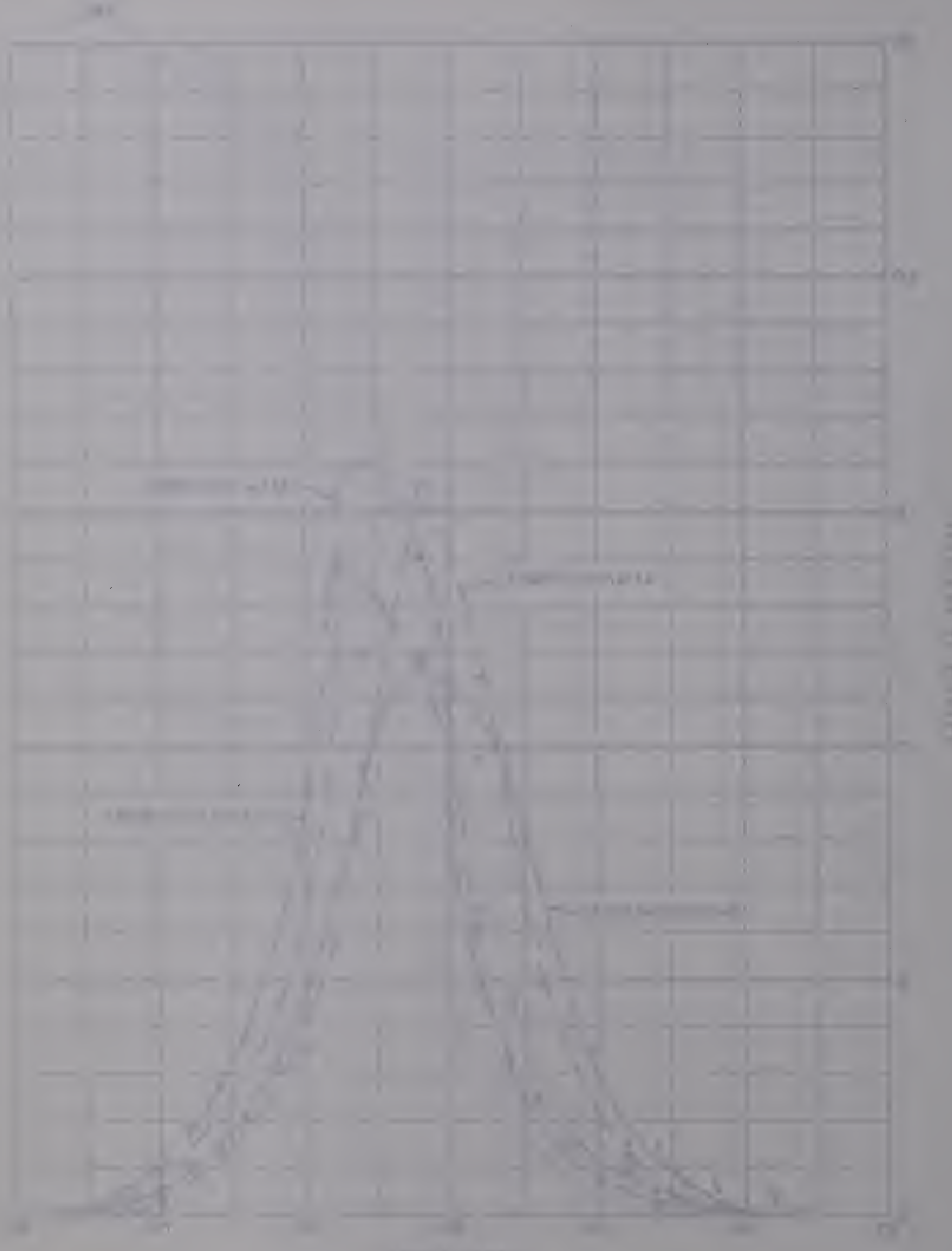
CUMULATIVE FREQUENCY
OF DAYTIME SPEEDS ON
CONTROL SECTION
FROM
RADAR MEASUREMENTS

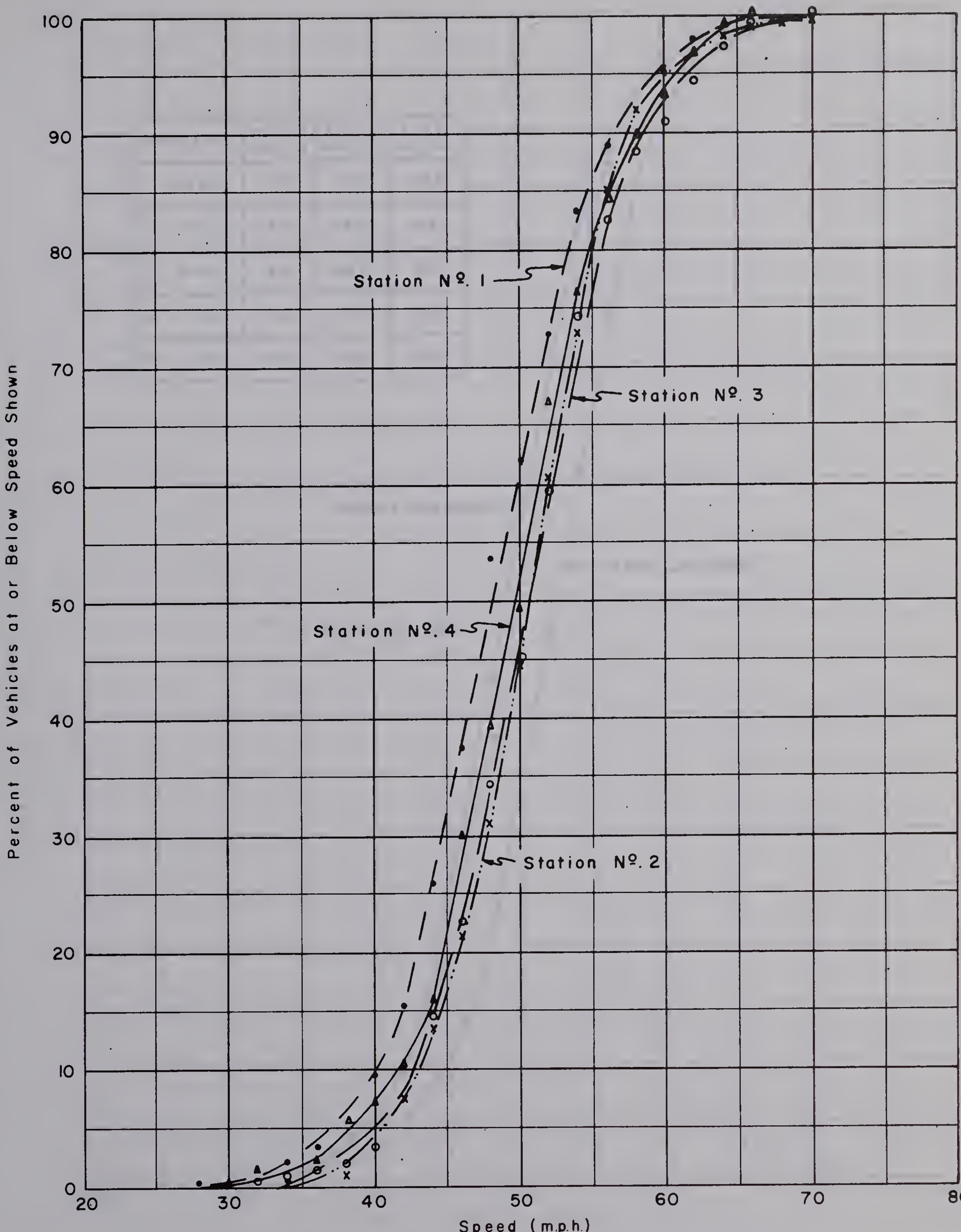
Figure 6·3



HISTOGRAM
OF DAYTIME SPEEDS ON
CONTROL SECTION
FROM
RADAR MEASUREMENTS

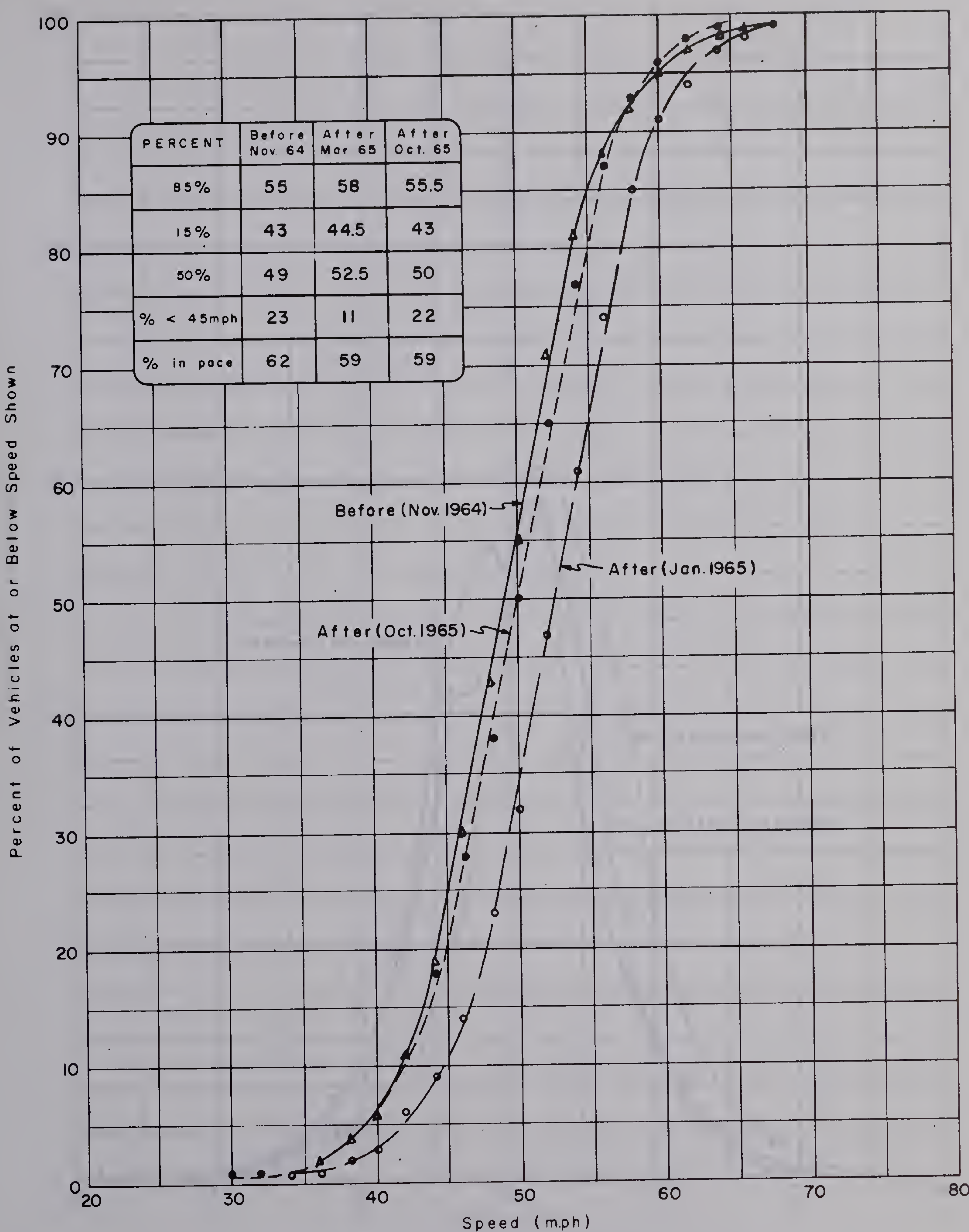
Figure: 6·4





CUMULATIVE FREQUENCY
OF DAYTIME SPEEDS AT
STATIONS 1,2,3,4
FROM RADAR MEASUREMENTS
MARCH, 1965

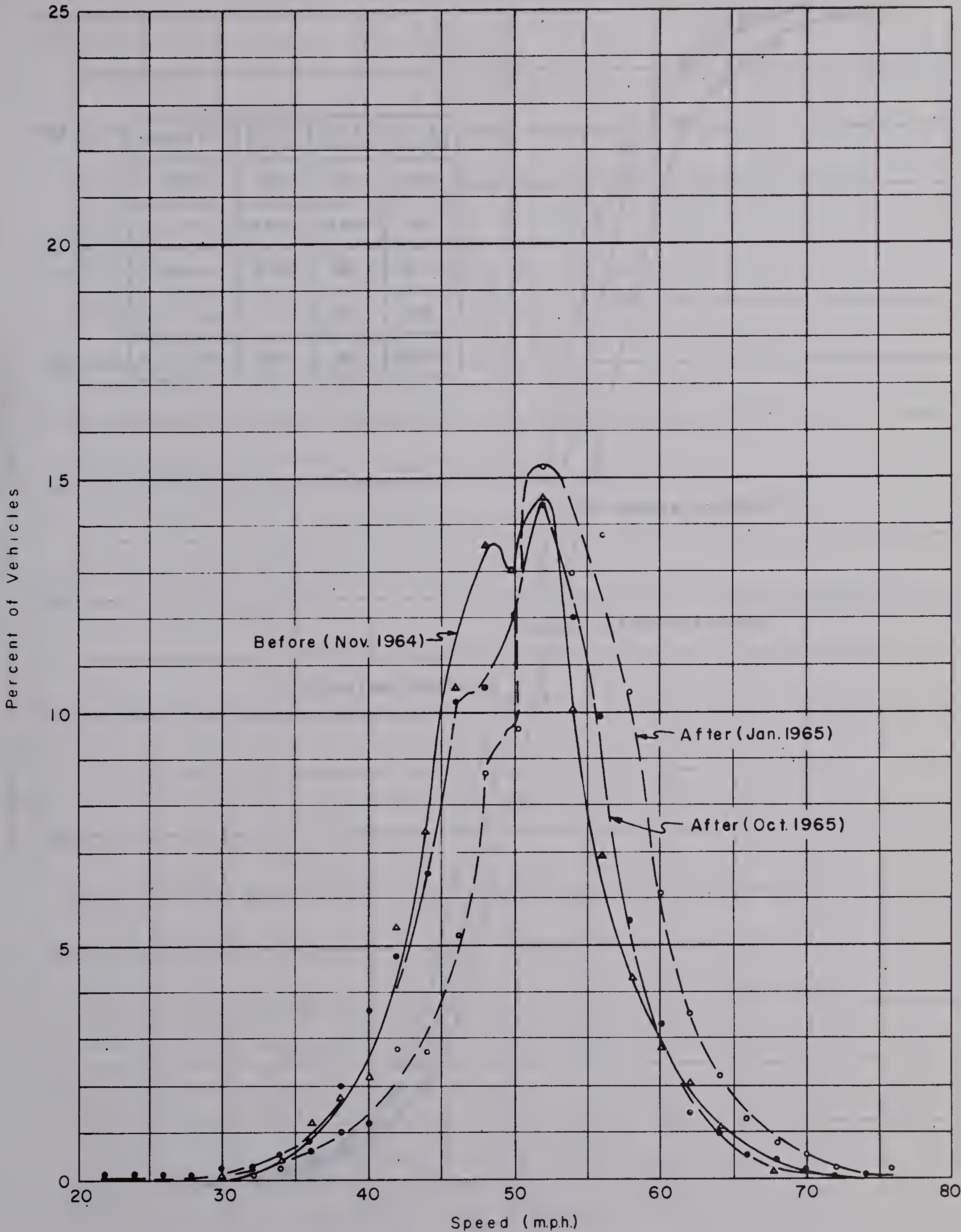
Figure: 6·5



PERCENT	Before Nov. 64	After Mar 65	After Oct. 65
85%	55	58	55.5
15%	43	44.5	43
50%	49	52.5	50
% < 45mph	23	11	22
% in pace	62	59	59

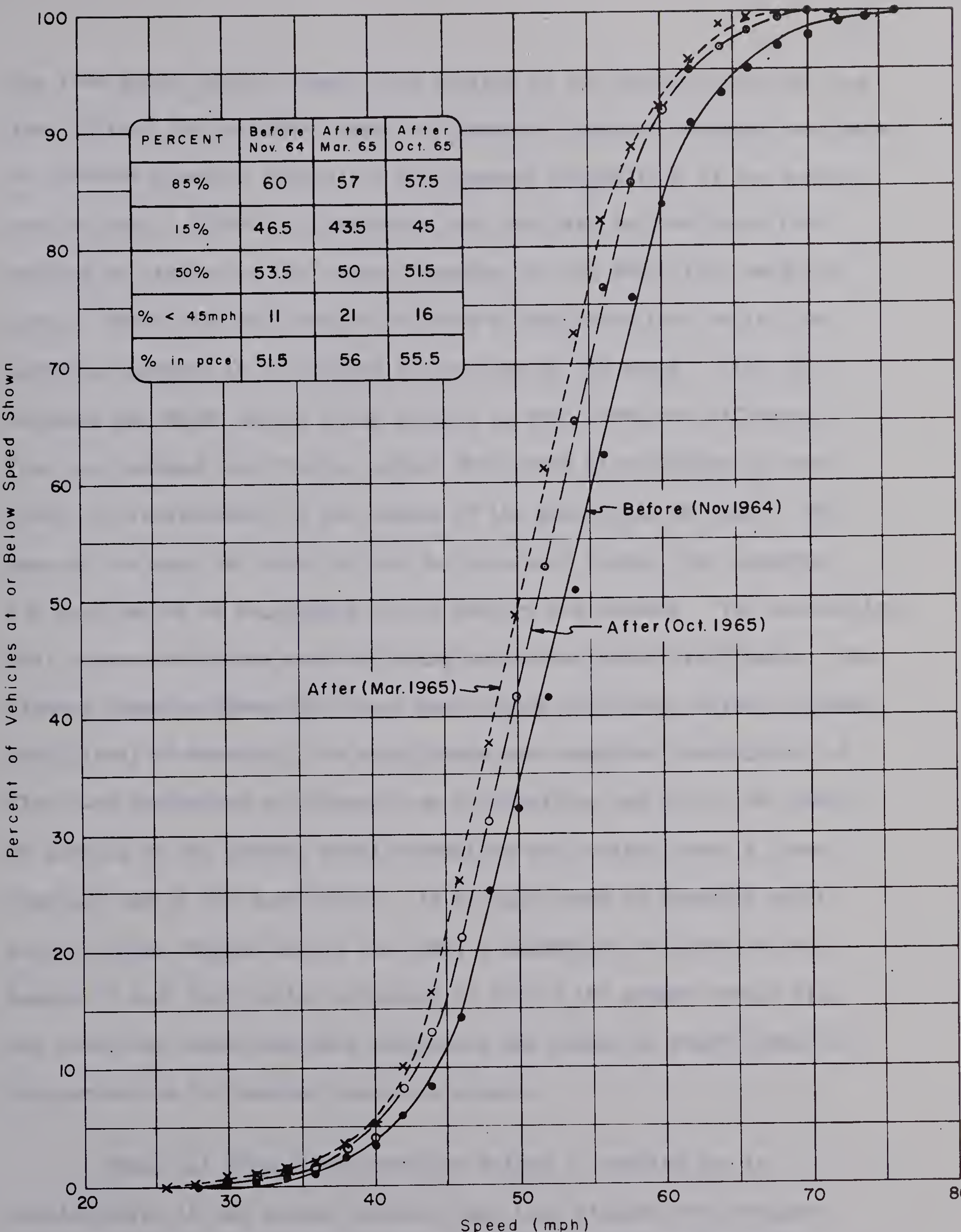
CUMULATIVE FREQUENCY
OF NIGHT SPEEDS ON
TEST SECTION
FROM
RADAR MEASUREMENTS

Figure : 6·6



HISTOGRAM
OF NIGHT SPEEDS ON
TEST SECTION
FROM
RADAR MEASUREMENTS

Figure: 6·7



PERCENT	Before Nov. 64	After Mar. 65	After Oct. 65
85%	60	57	57.5
15%	46.5	43.5	45
50%	53.5	50	51.5
% < 45mph	11	21	16
% in pace	51.5	56	55.5

CUMULATIVE FREQUENCY OF NIGHT SPEEDS ON CONTROL SECTION FROM RADAR MEASUREMENTS

Figure: 6·8

The four month "after" speeds were similar to the "before", and the one year "after" series again showed an increase. Various attempts were made to discover possible causes for the apparent instability of the control section data. FIGURE 6.5 indicates that the data is consistent from station to station on the control section for the March 1965 series of tests. Since this was found to be true of the other test series the variable appeared to be related to the time of the study. With the November and March series being similar to each other but different from the December and October series which were also similar to each other, no relationship to the season of the year could be found. The days of the week and hours of the day were also listed, and compared for each series of recordings but no pattern was evident. The possibility that volume variations were affecting speeds was also investigated. The Highway Capacity Manual (10) found that volume had little effect on speed until level of service B, in which there was occasional restriction of flow, was approached at volumes over 400 vehicles per hour. The level of service on the control section remained well within level A (free flowing) during the test period. As a rough check on possible short period volume changes during the test, a comparison was made of the length of each test period necessary to obtain the proper sample size. The resulting variations were very small and showed no relationship to the variations in recorded operating speeds.

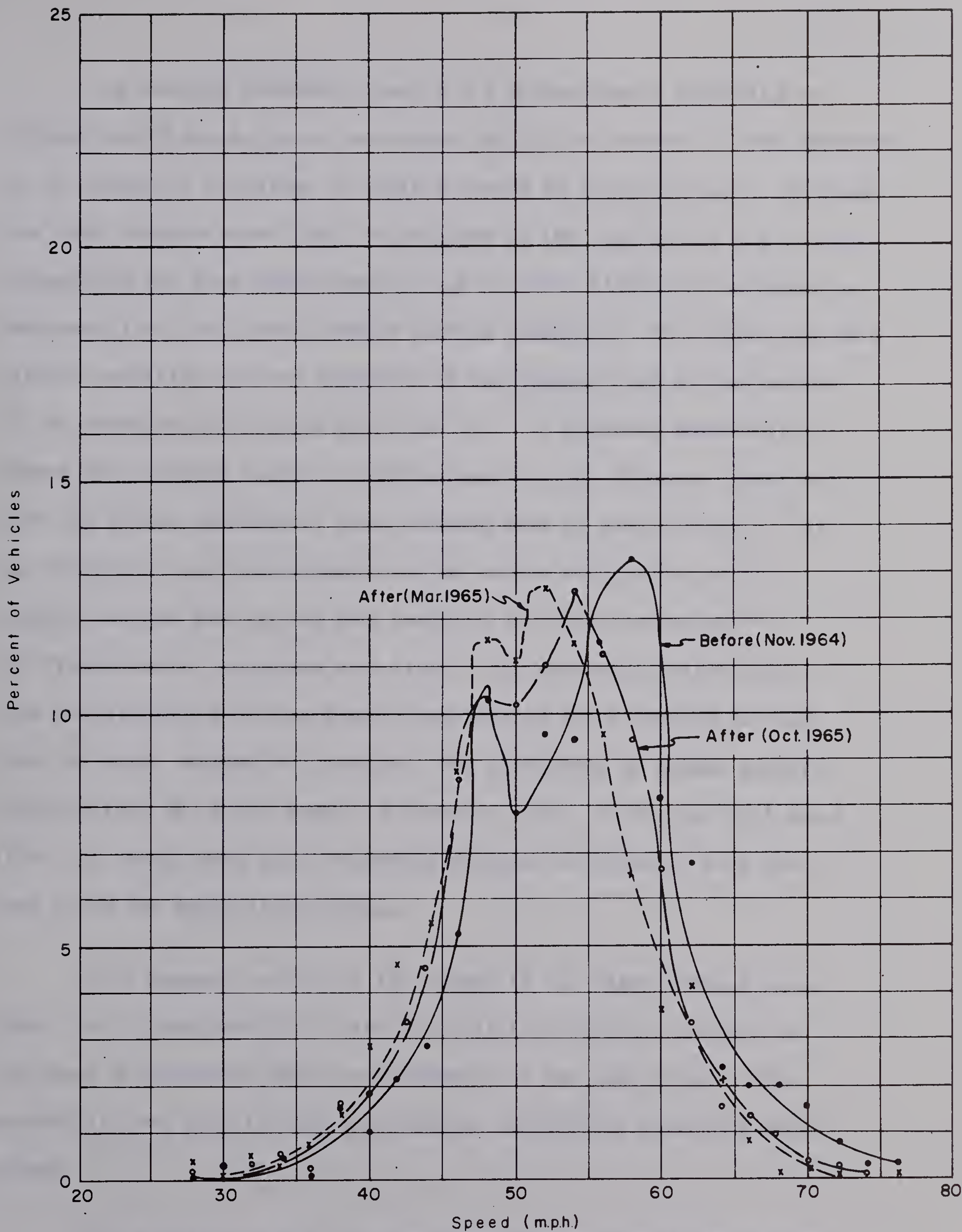
Since all other considerations failed to explain the inconsistencies it was deemed probable that they stemmed from changes in traffic composition. Since each series of readings was taken

within approximately a one week period it appeared that the proportions of traffic that were local compared to the proportion of through traffic, may have remained relatively constant for periods of at least one week but varied from season to season. Possible variations which could affect the composition of traffic in this way are; 1) the state of farm economy (year to year) could affect the number of farmers going to market, 2) significant events in Portage la Prairie or Brandon could increase the proportion of through traffic, 3) long distance travel could increase in holiday periods (December 1964), 4) the opening of the Roger's Pass may have increased the proportion of very long trips on the Trans-Canada Highway in 1965.

The composition of traffic on the test section on the other hand could have been more stable since it joined the two large traffic generators, Portage la Prairie and Winnipeg. If the proportion of through traffic was high in the first instance then the factors mentioned as affecting the control section would have a much lesser affect on the test section.

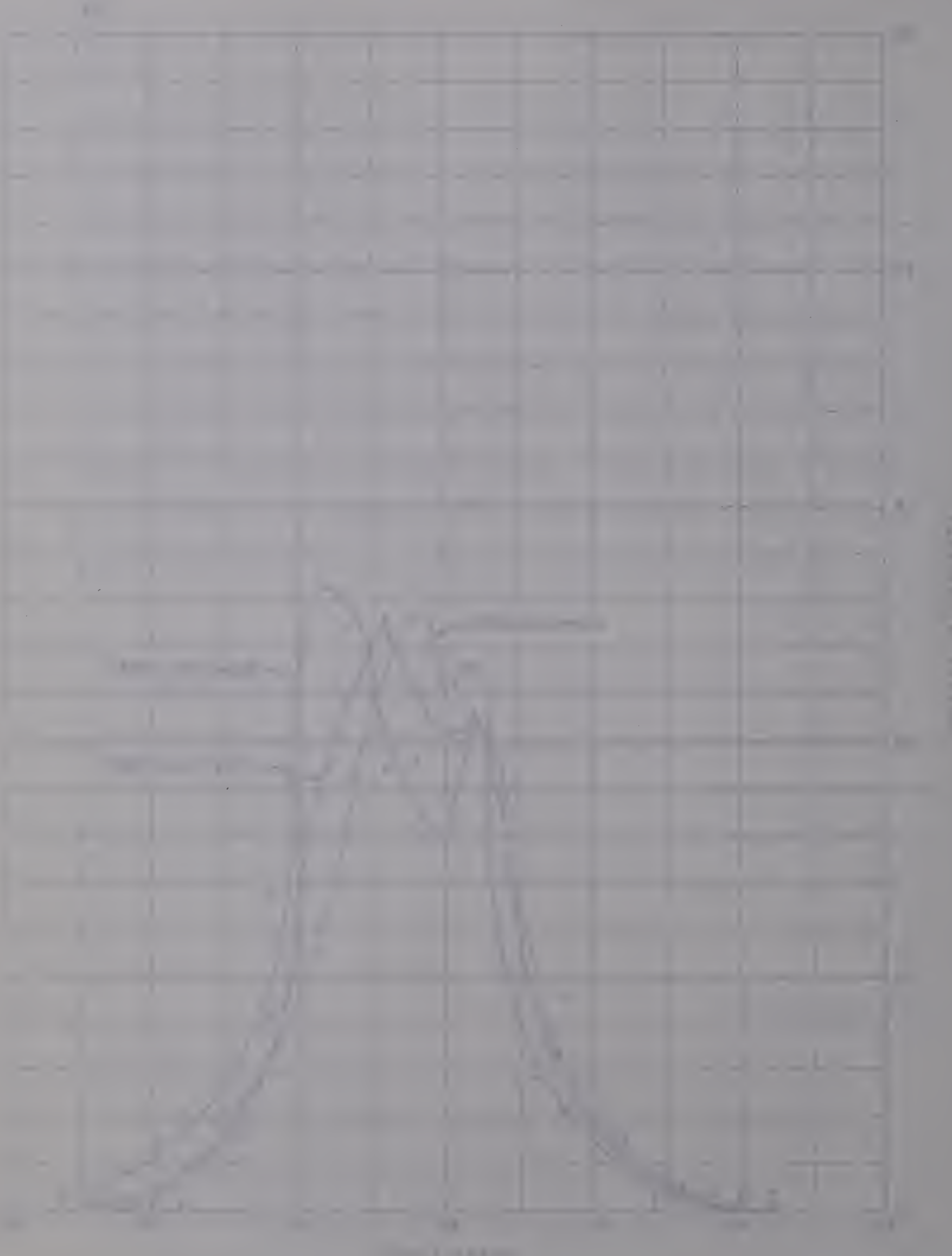
NIGHT SPOT SPEEDS

Consideration of FIGURES 6.6 and 6.8 revealed a reversed trend between control and test section at night. The "after" night speed curves for the test section lie to the right of the "before" curve indicating a slight increase in speeds. The "after" curves for the control section lie to the left of the "before" curve indicating a decrease in speeds.



HISTOGRAM
OF NIGHT SPEEDS ON
CONTROL SECTION
FROM
RADAR MEASUREMENTS

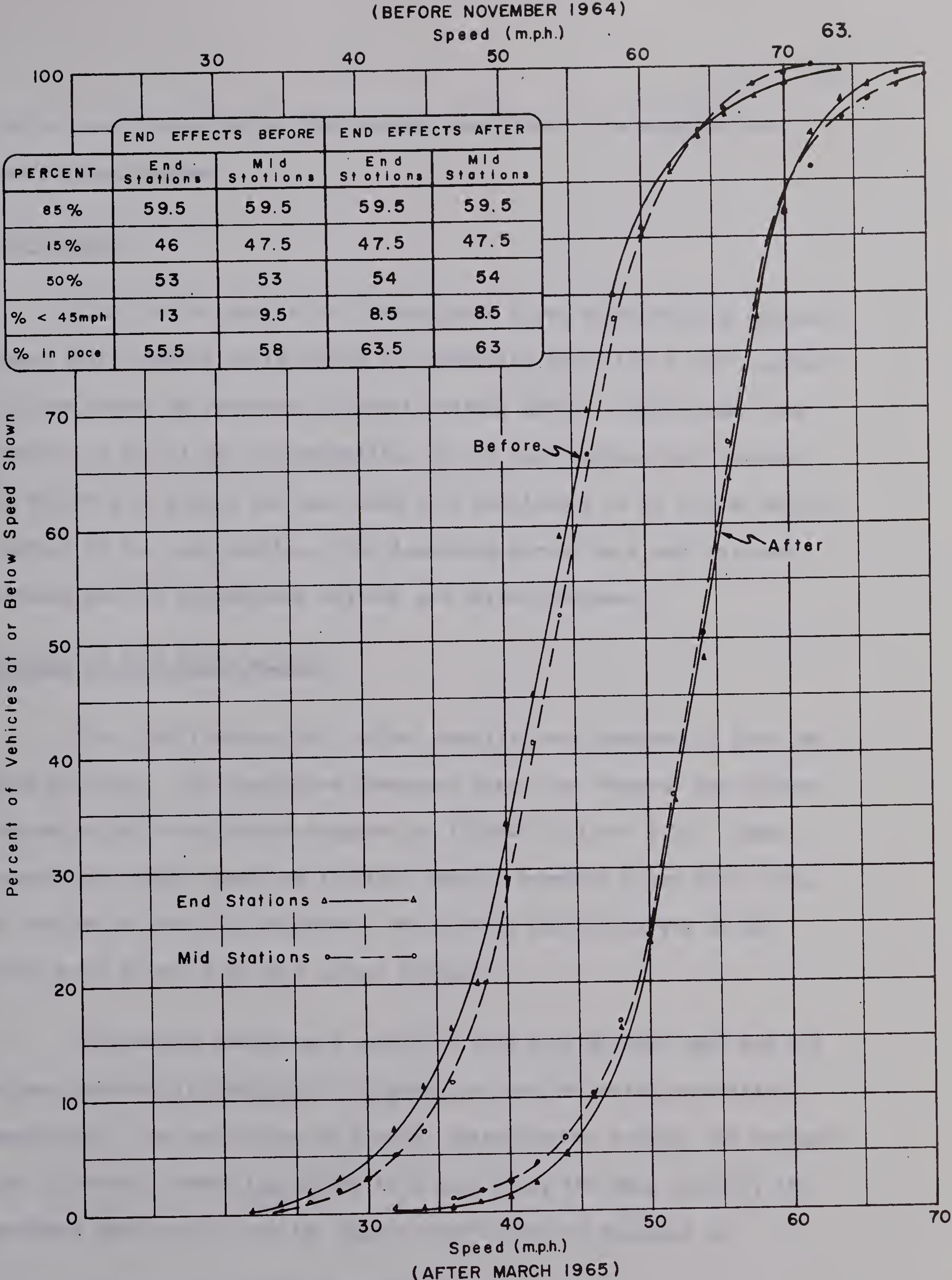
Figure: 6·9



In plotting FIGURES 6.7 and 6.9 a discontinuity occurring at or near the 50 m.p.h. point was evident on all six curves. These appeared to be caused by a cluster of vehicle speeds at about 48 m.p.h. Although the night maximum speed limit at the time of the test was 60 m.p.h. the change from the long established 50 m.p.h. night limit only occurred in September 1964, two months before testing commenced. The change was made without publicity and was indicated on the highway only by the removal of the standard night speed limit tab (5). It appeared reasonable to deduce that drivers tended to cluster near the old 50 m.p.h. limit and that the common speedometer error reduced this to about 48 m.p.h. It was noted that the discontinuity in the curves was greater on the control section than on the test section, and that the extent of the discontinuity decreased with time. This decreasing effect with time was attributed to the gradual realization among certain drivers that the night maximum had changed. The clustering of speeds involved approximately 5% of the sample in November 1964. In October 1965 about 1% of the sample were still clustered despite the lapse of more than a year since the speed limit change.

This apparent effect of the change in the night maximum speed limit led to consideration of the possibility that other changes in the speed distribution might be attributed to the same cause. This possibility was kept in mind when drawing conclusions regarding night speeds.

The possibility was also considered that discontinuities might occur on the test section histograms which would indicate a cluster in



PERCENT	END EFFECTS BEFORE		END EFFECTS AFTER	
	End Stations	Mid Stations	End Stations	Mid Stations
85 %	59.5	59.5	59.5	59.5
15 %	46	47.5	47.5	47.5
50 %	53	53	54	54
% < 45mph	13	9.5	8.5	8.5
% in pace	55.5	58	63.5	63

CUMULATIVE FREQUENCY OF SPEEDS ON TEST SECTION

END STATIONS COMPARED TO MID – STATIONS

Figure: 6·10

the 45 m.p.h. area due to the minimum speed limit. No such pattern was evident however.

END EFFECTS

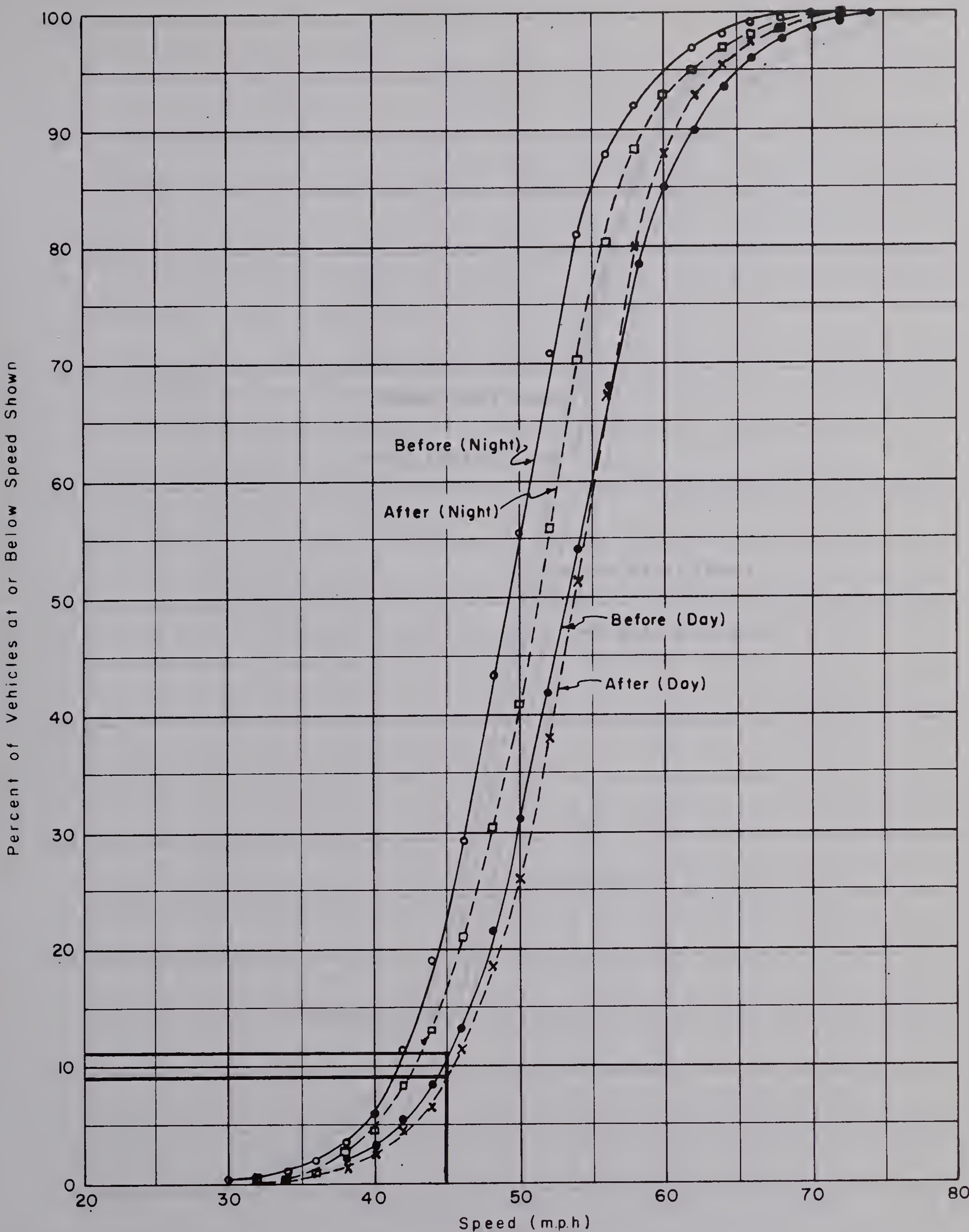
The initial impact on a driver when first confronted by minimum speed limit signing could affect his operating speed for a short period of time before he reverted to normal driving habits. Speed data from stations 6 and 11 at the extremities of the test section were plotted in FIGURE 6.10 beside the same data from stations 5 to 10 in the central portion of the test section. The resulting curves were well matched showing that no significant daytime end effects existed.

SUMMARY OF SPOT SPEED RESULTS

For clarification the "after" results were combined to form one data grouping. The cumulative frequency curve for "before" and "after" day and night were plotted together in FIGURES 6.11 and 6.12. These curves show night speeds on the test section somewhat lower than those in daytime as could be expected. The control section curves on the other hand do not show this normal tendency.

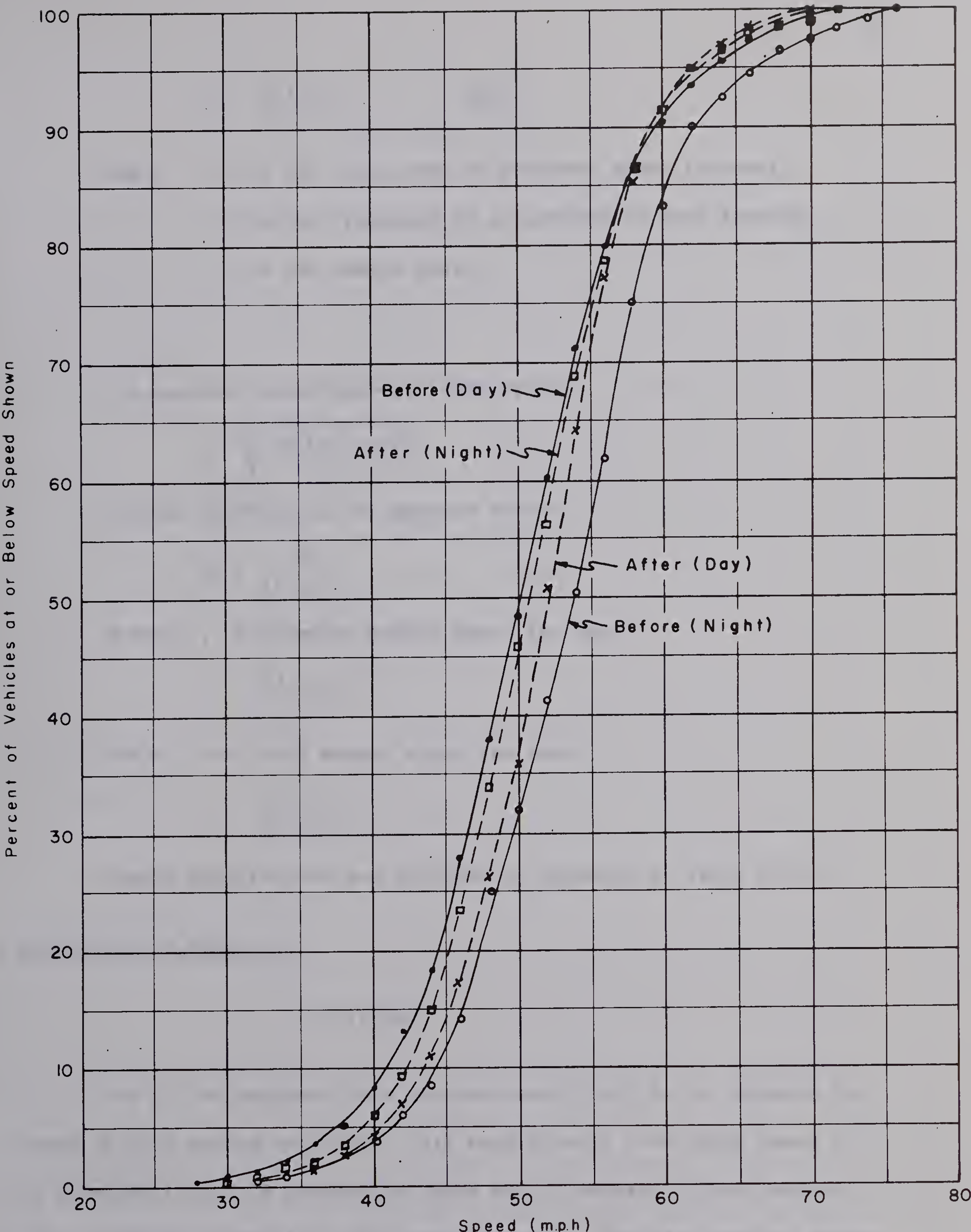
Percentile speeds were extracted from this grouped data and the values inserted in Table 6-I. In addition, the following quantities were shown: The percentage of traffic classified as trucks, the percentage of traffic travelling in the 10 m.p.h. pace, the mean speed $\bar{x}$, the standard deviation s, and the moment coefficient of skewness a_3.

The arithmetic mean was computed from:-



COMPOSITE
CUMULATIVE FREQUENCY
OF SPEEDS ON
TEST SECTION

Figure: 6·11



COMPOSITE
CUMULATIVE FREQUENCY
OF SPEEDS ON
CONTROL SECTION

Figure: 6·12

$$\bar{x} = \frac{\Sigma f(x)}{N} \qquad (29)$$

where x is the class mark of recorded speed intervals

f is the frequency of occurrence in each interval

N is the sample size.

The standard deviation was found from:-

$$S = \sqrt{\frac{\Sigma (f x^2) - N\bar{x}^2}{N - 1}} \qquad (9)$$

and the coefficient of skewness from:-

$$a_3 = \frac{m_3}{\sqrt{m_2^3}} \qquad (29)$$

where m_2, the second moment about the mean

$$= \frac{\Sigma f (x - \bar{x})^2}{N}$$

and m_3, the third moment about the mean

$$= \frac{\Sigma f (x - \bar{x})^3}{N}$$

Sample calculations are included in Appendix B, Table B-XIII.

DISCUSSION OF TABLE 6-I

DAYTIME

One of the purposes of a minimum speed limit is to increase the speed of slow moving vehicles. This result would show up by means of an increase in the 15 percentile speed and a decrease in the percentage of vehicles travelling less than 45 m.p.h. The test section showed a slight tendency toward both of these changes but the same changes with

Table 6-I

RADAR SPOT SPEED RESULTS

			Before	After	Change	% Change
% of traffic travelling less than 45 m.p.h.	Day	Test	11.0	9.0	-2.0	-18
		Control	22.0	14.0	-8.0	-36
	Night	Test	23.0	15.5	-7.5	-32
		Control	11.0	19.0	+8.0	+73
% of traffic travelling in the 10 m.p.h. pace increment	Day	Test	57.0	62.0	+5.0	+9
		Control	53.0	60.0	+7.0	+13
	Night	Test	62.0	61.5	-0.5	-1
		Control	51.5	55.5	+4.0	+8
Median Speed (50 Percentile)	Day	Test	53.5	54.0	+0.5	+1
		Control	50.0	52.0	+2.0	+4
	Night	Test	49.0	51.0	+2.0	+4
		Control	53.5	51.0	-2.5	-5
85 Percentile	Day	Test	60.0	59.0	-1.0	-2
		Control	57.5	57.5	0.0	0
	Night	Test	55.0	57.0	+2.0	+4
		Control	60.0	57.5	-2.5	-4
15 Percentile	Day	Test	47.0	47.5	+0.5	+1
		Control	43.0	45.5	+2.5	+6
	Night	Test	43.5	45.0	+1.5	+3
		Control	46.5	44.0	-2.5	-5

Table 6-I

RADAR SPOT SPEED RESULTS

			Before	After	Change	% Change
Speed Differential 85 - 15 Percentile	Day	Test	13.0	11.5	-1.5	-12
		Control	14.5	12.0	-2.5	-18
	Night	Test	11.5	12.0	+0.5	+4
		Control	13.5	13.5	0	0
% of traffic that are classified as trucks	Day	Test	20	17	-3	-15
		Control	15	16	+1	+7
	Night	Test	13	19	+6	+46
		Control	16	15	-1	-6
Arithmetic Mean Speed	Day	Test	54.2	54.4	+.2	1
		Control	51.1	52.6	+1.5	+3
	Night	Test	50.1	52.0	+1.9	+4
		Control	54.4	51.6	-2.8	-5
Standard Deviation	Day	Test	7.1	6.3	-0.8	-11
		Control	7.6	6.4	-1.2	-16
	Night	Test	6.4	6.5	+0.1	+2
		Control	7.4	6.8	-0.6	-8
Index of Skewness	Day	Test	-0.03	-0.30	normal to non-normal	
		Control	+0.04	-0.17	normal to non-normal	
	Night	Test	+0.22	-0.05	non-normal to normal	
		Control	-0.13	-0.12	non-normal to non-normal	

somewhat greater magnitude occurred on the control section. It is difficult, therefore, to attribute the improvements to the effects of the minimum speed limit. In any case it is doubtful whether the 2% decrease in the percentage travelling less than 45 m.p.h. had any significant effect on the operating characteristics of the highway.

A second desirable result of the minimum speed limit when combined with the maximum would be a decrease of speed dispersion. A reduction in vehicle conflicts should be realized the closer operating conditions approach uniform speed. A reduction in the speed differential and the standard deviation would indicate such an improvement as would an increase in the percentage of vehicles travelling in pace.

Again the data indicates this trend for all three methods of measurement for daytime speeds on the test section, and again the parallel and almost equal trends occurred on the control section. It was evident that improvements in speed dispersion could not be attributed to the minimum speed limit.

Taylor (33) found a definite relationship between the normality of speed distribution and accident frequency when the index skewness was used as the measure of normality. For a normal distribution the skewness index = 0. The daytime index of skewness indicated a change from a normal to non-normal distribution on both test and control section during daylight. This led to the expectation of an accompanying increase in accident rate which was found later to have indeed, occurred.

This adverse adjustment in normality of speed distribution appeared attributable to some cause other than the minimum speed limit, since the variation was the same for test and control section.

The relative proportions of trucks in the traffic stream has a significant effect on traffic speeds (10). Since this proportion varied by no more than 4% from the reported average of 16.2% it was assumed that any resulting effects remained constant throughout the test period.

NIGHT

The measures of change in the low speed range at night show a much different situation than occurred in daylight. The percentage of vehicles under 45 m.p.h. decreased significantly on the test section and increased on the control section. Similarly the 15 percentile increased on the test section and decreased on the control section. This indicated a change in night speed pattern which could be attributed to the minimum speed limit. The delayed effect of the raising of the night maximum speed would not alter the meaning of these results provided these effects were the same on both test and control section. The maximum had been raised in both areas at the same time.

All three measures of dispersion indicated little change from "before" to "after". The percent of vehicles in pace and the standard deviation showed an 8% improvement on the control section which did not occur on the test section.

The normality of the night speed distributions from the index

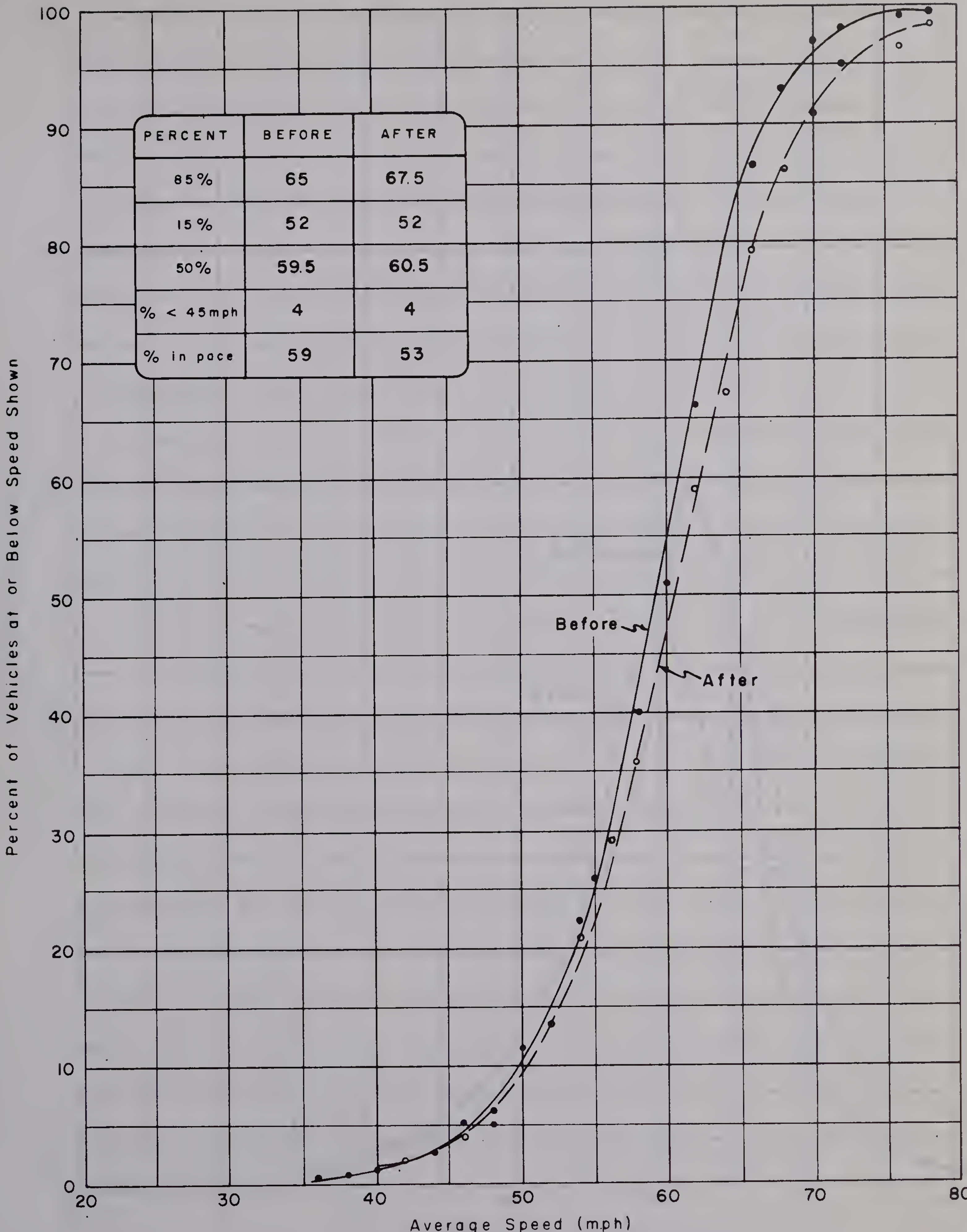
of skewness test changed in the case of the test section from non-normal to normal and remained non-normal on the control section. This led to anticipation of an improvement in the nighttime accident rate on the test section which would not be evident on the control section. Subsequent examination of accident records partially support this deduction inasmuch as the very heavy increase in proportion of nighttime accidents on the control section was matched by a much smaller increase on the test section.

AVERAGE SPEEDS

The two measures of central tendency, the median speed and the mean speed show little change for either day or night but the variations that do occur are consistent between both parameters.

The statistical significance of the mean speed differences was investigated using the Aspin-Welch test of an hypothesis (35). This test revealed that the difference in mean speeds for the test section in daylight was not significant but the other three differences were well within the bounds of statistical significance at the 99% confidence level. This means that there was less than a 1% probability that the difference in "before" and "after" mean speeds were the result of mere chance. The large sample sizes used in the test insured the desired statistical accuracy in the other parameters.

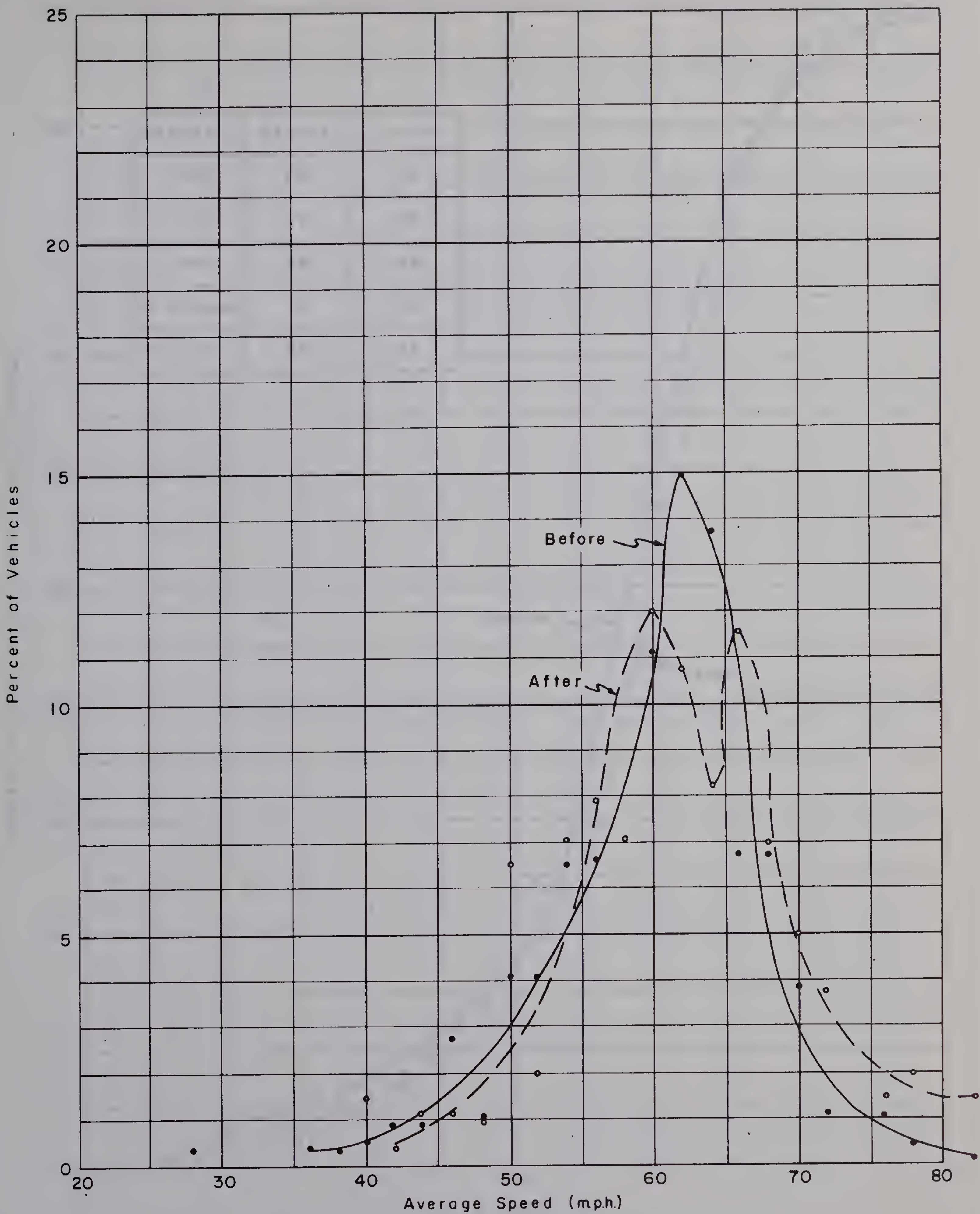
There was a practical significance also in the nighttime change in the mean and median speeds. The increase for the test section compared to the corresponding decrease for the control section indicated



PERCENT	BEFORE	AFTER
85%	65	67.5
15%	52	52
50%	59.5	60.5
% < 45mph	4	4
% in pace	59	53

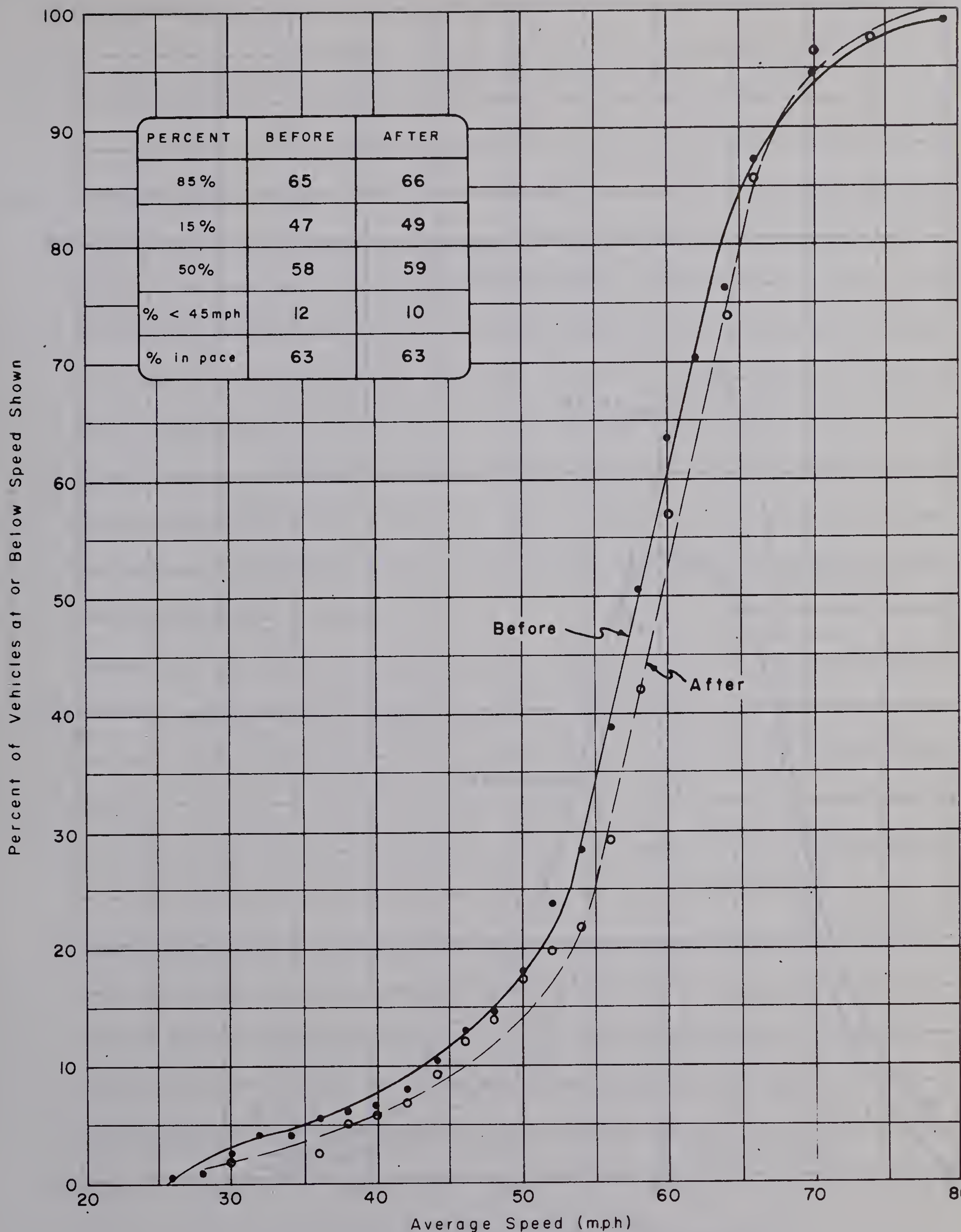
CUMULATIVE FREQUENCY
OF SPEEDS ON
TEST SECTION
FROM
TRAVEL TIME MEASUREMENTS

Figure : 6·13



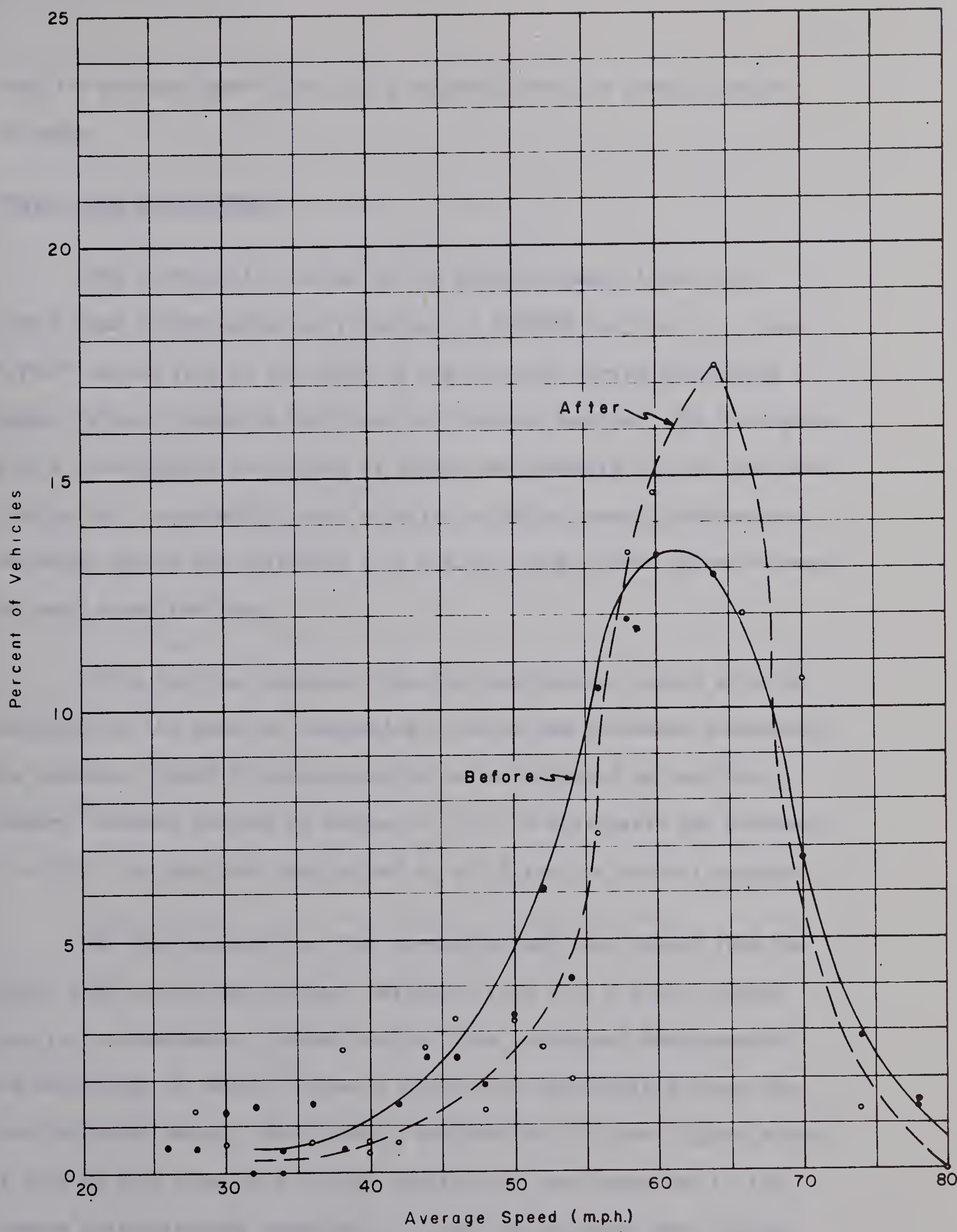
HISTOGRAM
OF SPEEDS ON
TEST SECTION
FROM
TRAVEL TIME MEASUREMENTS

Figure: 6·14



CUMULATIVE FREQUENCY
OF SPEEDS ON
CONTROL SECTION
FROM
TRAVEL TIME MEASUREMENTS

Figure : 6·15



HISTOGRAM
OF SPEEDS ON
CONTROL SECTION
FROM
TRAVEL TIME MEASUREMENTS

Figure: 6·16

that the minimum speed limit had a buoyant effect on average speeds at night.

TRAVEL TIME MEASUREMENTS

The distribution curves of the average speeds taken from travel time measurements are presented in FIGURES 6.13 to 6.16. Both "after" curves fall to the right of the "before" curves indicating higher "after" speeds on both test and control section. The histograms show a considerable scattering of points, particularly for the test section "after" curve which shows a definite double peaked distribution. The modal speeds are uniformly 4 to 5 m.p.h. higher than those recorded for spot speed readings.

Table 6-II was compiled from the distribution curves with the exception of the index of overtaking Ov which was calcuated separately. The constant c used in calculating Ov was established so that both "before" studies yielded Ov values to 1.0. On this basis the constant $c_t = 11.2$ for the test section and $c_c = 7.8$ for the control section.

The 50th percentile, 15th percentile and mean speeds from the travel time recordings produced values of from 6 to 8 m.p.h. higher than the corresponding values derived from spot speed measurements. The percentage of traffic below 15 m.p.h. was considerably lower than from the radar tests. The probable explanation for these higher speeds is that in this case only through traffic was considered due to the license plate matching technique. It could be expected that through traffic would be moving at somewhat higher speeds than would local

Table 6-II

PERCENTILE SPEEDS & OVERTAKING

INDEX FROM TRAVEL TIME STUDY

	Section	Before	After	Change	% Change
Percent of traffic travelling below 45 m.p.h.	Test	4	4	0	0
	Control	12	10	-2	-17
50th Percentile Median Speed	Test	59.5	60.5	+1.0	+2
	Control	58.0	59.0	+1.0	+2
15th Percentile	Test	52.0	52.0	0	0
	Control	47.0	49.0	+2.0	+4
Arithmetic Mean Speed	Test	58.2	59.4	+1.2	+2
	Control	55.3	56.5	+1.2	+2
% of Vehicles in 10 m.p.h. pace	Test	59.0	53.0	-6.0	-10
	Control	63.0	63.0	0	0
Index of Overtaking	Test	1.00	0.83	-.17	-17
	Control	1.00	0.90	-.10	-10

vehicles on short runs.

The changes in the above four variables confirm the results of the spot speed studies in all respects. Slight increases in the mean, median and 15 percentile speeds for both test and control section again give a strong indication that the minimum speed effects in daytime are minimal.

The percentage of vehicles in pace remained in the same general range as that found from the spot speed studies,indicating that through traffic speeds are dispersed about the mean to approximately the same degree as are those of the total traffic.

The index of overtaking decreased on both the test and control sections "after" the speed limit installation. This indicated a reduction in passing occurrences per vehicle mile per unit of density. Since all the measures of dispersion of speed indicated that speeds were more uniform for the "after" period than "before" it could be reasoned that the reduction in overtaking index should be expected. This lower overtaking index cannot be attributed to the speed limit change, however, because the decrease occurred on the control section as well as the test section. The index itself appears to be valid and may be found useful in future travel time studies.

ACCIDENT ANALYSIS

Accident data was collected for three 1 year periods. Years 1 and 2 were prior to the minimum speed limit and the after data was

Table 6-III

ACCIDENT STATISTICS

TEST SECTION - LENGTH 33.0 MILES

Year		Total Accids.	Vehicles miles (millions)	Accid. rate per M.V.M.	Total fatal & injury Accids.	Total killed & injured	Severity ratio (%)	Total property damage $	Day-light Accids. No.	Day-light Accids. %	Night Accids. No.	Night Accids. %	Accids. involving passing No.	Accids. involving passing %	Total vehicles involved in Accids.	% of involved vehicles that are commercial
1 Dec.1/62 Dec.1/63		48	44.2	1.08	19	34	39.6	87,585.	21	44	27	56	10	20.8	83	14.5%
2 Dec.1/63 Dec.1/64		69	47.8	1.44	27	72	39.1	60,774.	42	61	27	39	18	26.5	122	6.6%
Average 1 & 2 (before)		58.5	46.0	1.27	23	53	39.4	74,179.	31.5	54	27	46	14	23.7	102.5	10.6%
3 Dec.1/64 Dec.1/65 (after)		75	52.1	1.44	30	52	40.0	79,010.	34	48	39	52	12	16.0	162*	9.9%
Change from 1 & 2 average	No.	+17.5	+6.0	+0.17	+7	-1	+0.6	5,831.	+5.5				-2	-7.7	+59.5	-0.7%
	%	+28.2	+13.3	+13.4	+30.4	-1.9	+0.6	+6.5	+14.3	-6	+44.4	+6	-14.3	-7.7	+58.0	-0.7%

* Affected by one 27 car accident in year 3

Table 6-IV

ACCIDENT STATISTICS

CONTROL SECTION - LENGTH 22.0 MILES

Year		Total Accids.	Vehicle miles millions	Accids. rate per M.V.H.	fatal & injury Accids.	Total killed & injured	Severity ratio (%)	Total property damage $	Day-light Accids. No.	Day-light Accids. %	Night Accids. No.	Night Accids. %	Accids involving passing No.	Accids involving passing %	Total vehicles involved in Accids.	% of involved vehicles that are commercial
1 Dec.1/62 Dec.1/63		22	22.7	0.97	7	14	31.8	11,705.	16	73	6	27	2	91	32	12.5%
2 Dec.1/63 Dec.1/64		25	24.1	1.04	9	26	36.0	20,605.	13	52	12	48	8	32.0	44	15.9%
Average 1 & 2 (before)		23.5	23.4	1.00	8	20	33.9	16,155.	14.5	62	9	38	5	20.6	38	14.2%
3 Dec.1/64 Dec.1/65 (after)		32	27.3	1.17	12	29	37.5	66,768.*	14	44	18	56	5	15.6	54	22.2%
Change from 1 & 2 Average	No.	+8.5	+3.9	+0.17	+4	+9		50,613.	-0.5		-9		0		16	
	%	+36.2	+16.6	+17.0	+50.0	+45.0	+3.6	+313.3	-3.4	-18	100	+18	0	-5.0	+42.1	+8.0%

*3 Accidents involved $45,700.00

compiled under year 3. In Tables 6-III and 6-IV were listed the accidents in total, by severity, day and night and in passing involvement along with the vehicle miles and accident rates. The changes from the average of years 1 and 2 (before) to year 3 (after) were calculated and inserted in the table.

Separate vehicle miles for day and night were not available so that overall accident rates only were calculated.

The control section accident data fluctuates considerably because annual accident occurrence of 25 to 30 gives unreliable results especially when broken down further into categories such as day and night. The accidents per million vehicle miles which was the most stable figure for comparison indicated a 17% increase on the control section compared to a rise of 13.4% on the test section. Increases in both of these rates were predicted in considering the normality of speed distribution as indicated by the index of skewness.

The control section also showed a greater increase in the severity ratio and proportion of night accidents than did the test section. It was difficult to attribute the many changes to the speed limit because of the short accident record and the small range of differences. In any case the general trends were the same on the control section as on the test section for most categories.

It was interesting to note that the involvement of commercial vehicles in accidents was about 10% and the corresponding percentage of traffic that is commercial was about 16%. This agrees with the

Bureau of Public Roads (28) finding that the accident involvement rate for trucks is lower than for traffic as a whole.

Correlation was noted between the reduction in Ov and reduction in accidents involving passing manoeuvres. Both of these values dropped approximately equally on test and control section. This further supported the validity of the use of the overtaking index as a measure of passing activity.

SPEED PROFILES

The speed profiles shown in FIGURES 6.17 and 6.18 were drawn up to bring into perspective the geographic distribution of speeds and accidents. Also illustrated were the location of buildings on the route, speed limit signs, radar stations and intersecting highways. The 85 and 15 percentile speeds were indicated graphically for comparison with the speed limits. The annual average daily traffic flow and the accident rates derived therefrom were also shown.

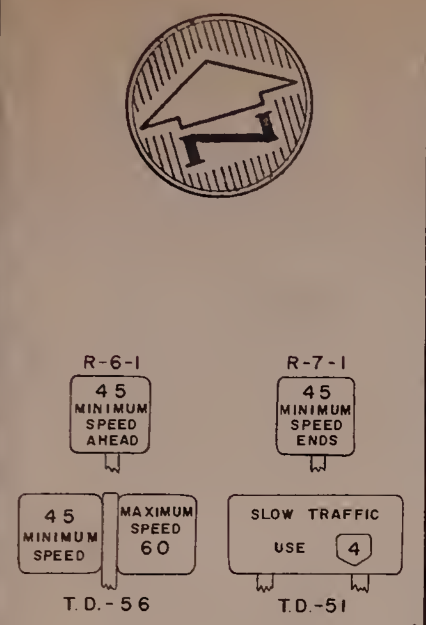
The occurrence of accidents on the test section was more heavily concentrated than on the control section. Accidents were evenly distributed over the length of both sections with only slight clustering at intersections.

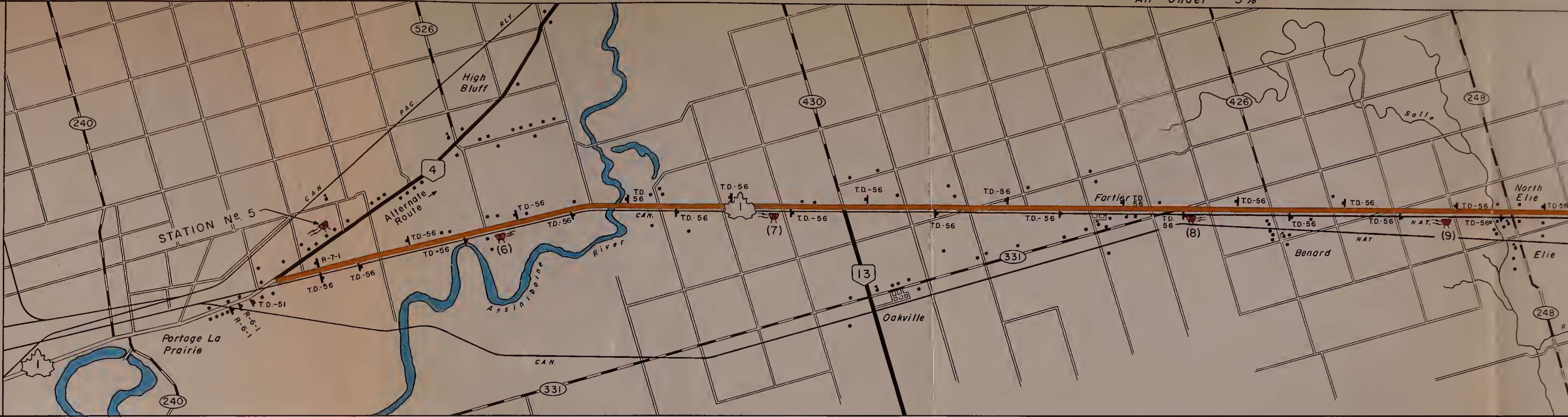
ALTERNATE ROUTE

The results of the radar spot speed readings on the alternate route are given in Table B-XII. The median speed did not change significantly at either station. An increase was recorded in the

ALIGNMENT	All Under 3°
GRADIENT	All Under 3%

REMARKS :





		STATION Nº. 6		STATION Nº. 7				STATION Nº. 8		STATION Nº. 9	
Nº OF LANES		2 Lanes									
TRAFFIC VOLUME	BEFORE	3880 A. A. D. T.						3480 A. A. D. T.			
	AFTER	4920 A. A. D. T.						4030 A. A. D. T.			
85 PERCENTILE	BEFORE	DAY 61	NIGHT 57	DAY E.B. 56	NIGHT E.B. 55	DAY W.B. 61	NIGHT W.B. 58	DAY 60	NIGHT 53	DAY 62	NIGHT 55
	AFTER	60	57	59	56	59	57	60	57	57	57
15 PERCENTILE	BEFORE	48	46	45	45	48	45	48	41	50	45
	AFTER	47	46	46	44	48	44	46	44	45	45
% VEHICLES IN PACE	BEFORE	56	65	68	68	59	57	58	61	57	68
	AFTER	64	62	59	64	64	55	61	62	64	61

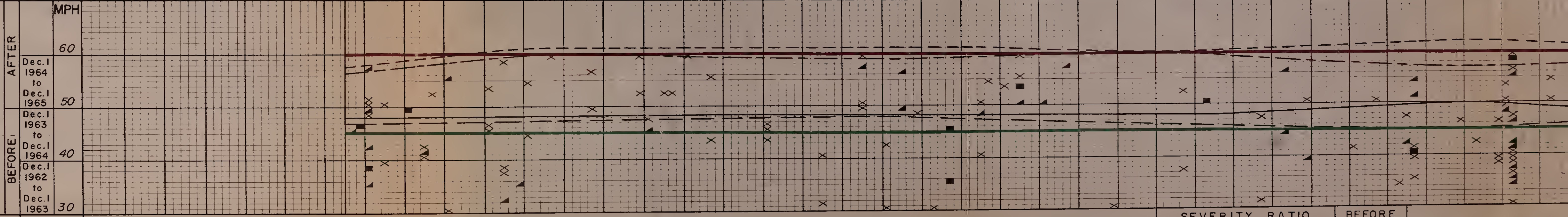
ACCIDENT LEGEND

PROP. DAM. ONLY

NON FATAL

FATAL

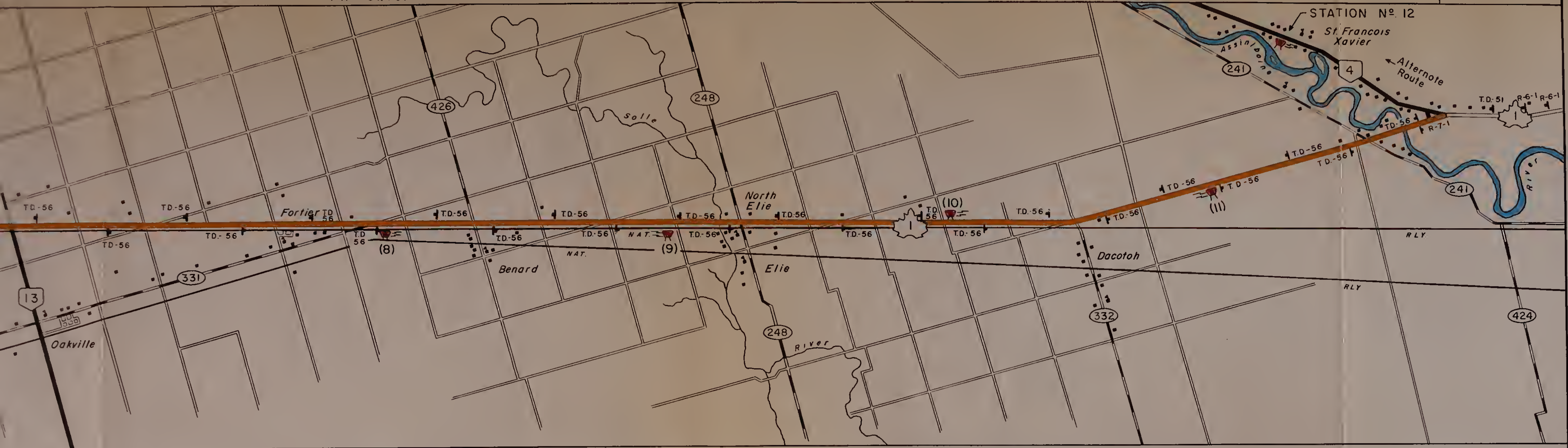
PEDESTRIAN



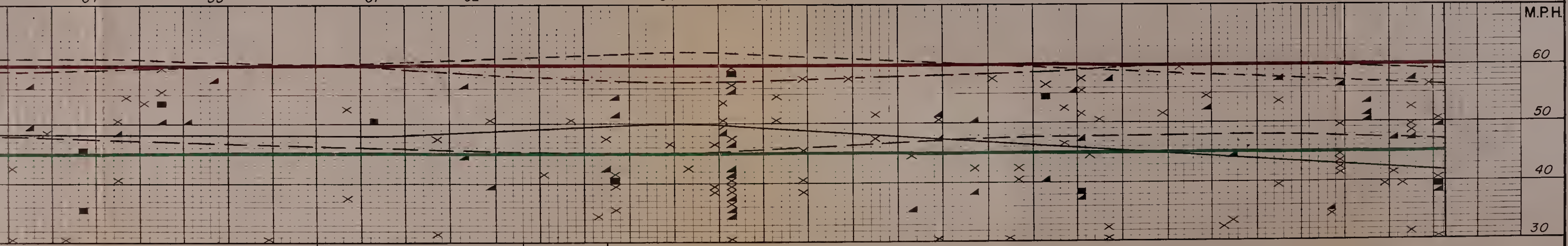
ACCIDENT RATE	BEFORE	1.27 Accidents per Million Vehicle Miles	SEVERITY RATIO	BEFORE
	AFTER	1.44 Accidents per Million Vehicle Miles	SEVERITY RATIO	AFTER

All Under 3°

All Under 3%



	STATION Nº 8	STATION Nº 9	STATION Nº 10	STATION Nº 11
	2 Lanes			
	3480 A. A. D. T.		3680 A. A. D. T.	
	4030 A. A. D. T.		4130 A. A. D. T.	
Y W.B. 61 NIGHT W.B. 58	DAY 60 NIGHT 53	DAY 62 NIGHT 55	DAY 60 NIGHT 53	DAY 58 NIGHT 53
59 57	60 57	57 57	58 57	60 56
48 45	48 41	50 45	47 43	44 42
48 44	46 44	45 45	47 45	48 45
59 57	58 61	57 68	60 65	53 66
64 55	61 62	64 61	61 59	59 61



SEVERITY RATIO	BEFORE	39.4 %
SEVERITY RATIO	AFTER	40.0 %

MINIMUM SPEED LIMIT SKETCH PLAN

UNIVERSITY of ALBERTA

EDMONTON · 1966

TEST SECTION

TRANS-CANADA HIGHWAY

MANITOBA HIGHWAY Nº 1

FROM – JCT. OF HWY Nº. 4, WEST OF HEADINGLEY, MANITOBA

TO – JCT. OF HWY Nº. 4, EAST OF PORTAGE LA PRAIRIE, MANITOBA.

TOTAL DISTANCE – 33 MILES

APPROX. SCALE: 3/4" = 1 MILE

– LEGEND –

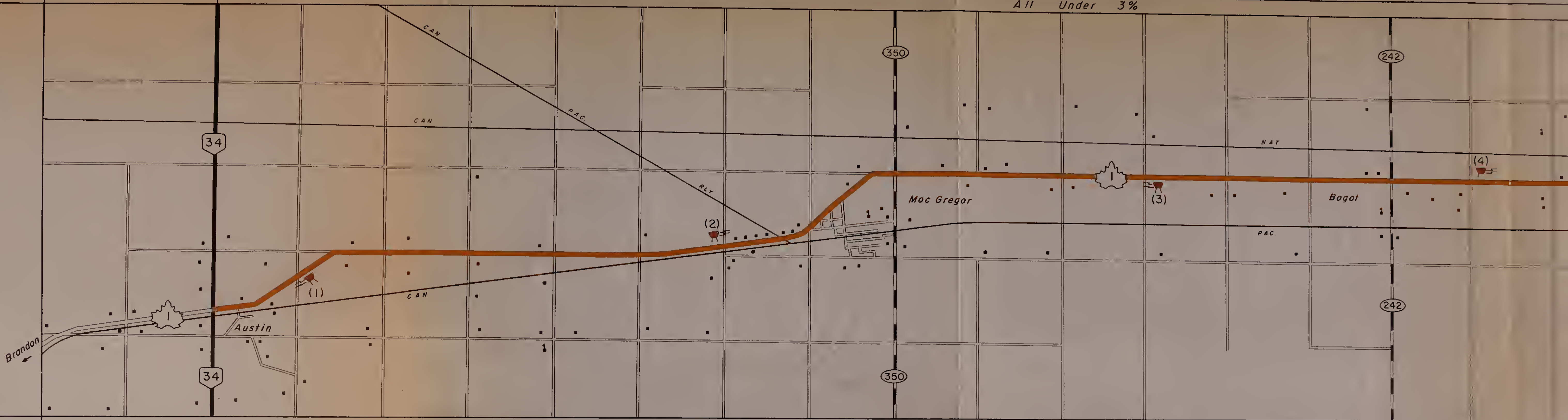
- BUILDINGS
- SCHOOLS
- TRANS-CANADA HWY.
- PROVINCIAL HIGHWAYS
- PROVINCIAL ROADS
- OTHER ROADS
- ROAD SIGNS (code no.)
- TRAFFIC SIGNALS
- 85 % SPEED – BEFORE / AFTER
- 15 % SPEED – BEFORE / AFTER
- MAXIMUM SPEED LIMIT
- MINIMUM SPEED LIMIT

NOTES :-

Figure: 6·17

ALIGNMENT	35° · 35° · 4°
GRADIENT	All Under 3%

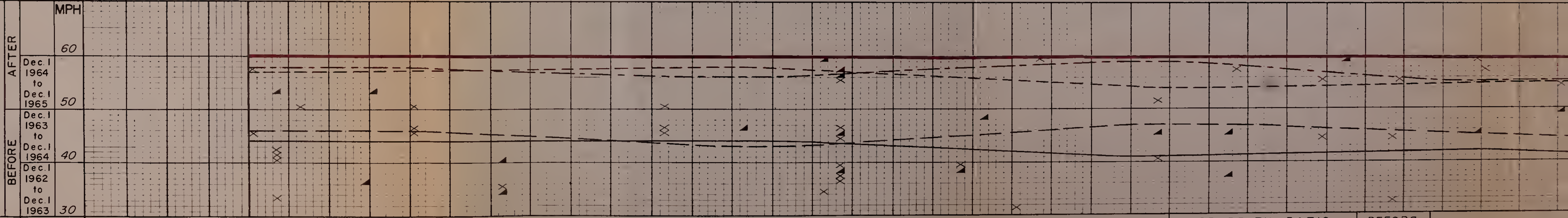
REMARKS :



STATION Nº.		STATION Nº 1		STATION Nº 2		STATION Nº 3		STATION Nº 4	
Nº OF LANES		2 Lanes							
TRAFFIC VOLUME	BEFORE	2760 A.A.D.T.							
	AFTER	3320 A.A.D.T.							
85 PERCENTILE	BEFORE	DAY 57	NIGHT 62	DAY 58	NIGHT 61	DAY 54	NIGHT 59	DAY 55	NIGHT 60
	AFTER	58	57	56	56	59	58	55	57
15 PERCENTILE	BEFORE	44	47	44	47	41	45	42	48
	AFTER	46	44	43	44	47	47	45	44
% VEHICLES IN PACE	BEFORE	58	59	58	55	57	55	60	60
	AFTER	59	52	58	59	60	63	66	58

ACCIDENT LEGEND

PROP DAM ONLY
NON FATAL
FATAL
PEDESTRIAN



ACCIDENT RATE				
BEFORE	1.00 Accidents per Million Vehicle Miles	SEVERITY RATIO	BEFORE	
AFTER	1.17 Accidents per Million Vehicle Miles	SEVERITY RATIO	AFTER	

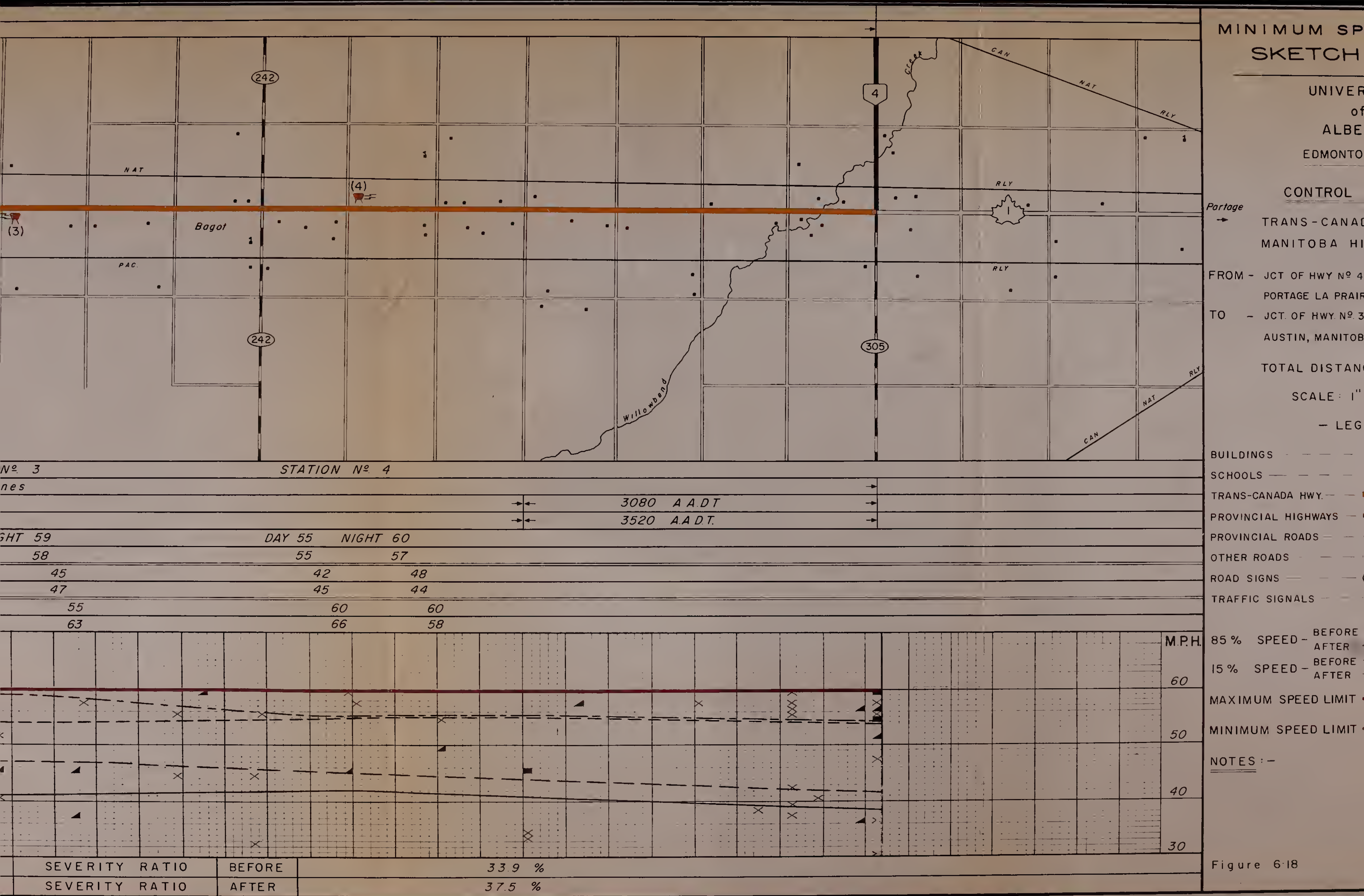

MINIMUM SP
SKETCH
UNIVER
of
ALBE
EDMONTO
CONTROL
Portage
TRANS-CANAD
MANITOBA HI
FROM - JCT OF HWY Nº 4
PORTAGE LA PRAIR
TO - JCT. OF HWY Nº 3
AUSTIN, MANITOB
TOTAL DISTANC
SCALE: 1"
– LEG
BUILDINGS
SCHOOLS
TRANS-CANADA HWY.
PROVINCIAL HIGHWAYS
PROVINCIAL ROADS
OTHER ROADS
ROAD SIGNS
TRAFFIC SIGNALS
85 % SPEED - BEFORE AFTER
15 % SPEED - BEFORE AFTER
MAXIMUM SPEED LIMIT
MINIMUM SPEED LIMIT
NOTES: –
CAN NAT RLY
RLY
Creek
Willowbend
NAT
PAC.
Bagot
(3)
(4)
242
4
305
1
Nº 3
STATION Nº 4
nes
3080 A.A.D.T
3520 A.A.D.T.
GHT 59
DAY 55 NIGHT 60
58
55 57
45
42 48
47
45 44
55
60 60
63
66 58
M.P.H.
60
50
40
30
SEVERITY RATIO BEFORE 33.9 %
SEVERITY RATIO AFTER 37.5 %
Figure 6·18

Table 6-V

ROADSIDE INTERVIEW RESPONSES

	Question	Response Classifications	Interview #1 East Bound	Interview #2 West Bound	Combined
No. 2	What are the speed limits on this highway?	Correct response	41.0	46.2	42.9
		Maximum speed only, correct	50.0	42.8	47.4
		Minimum speed only, correct	1.4	1.3	1.3
		Incorrect or don't know	7.6	9.7	8.4
No. 3	Did you increase your speed because of the minimum speed limit?	Yes	10.9	6.5	9.1
		No	86.7	90.4	88.2
		Don't know	2.4	3.1	2.7
No. 4	Interview #1 - Do you think minimum speed limits are a good idea?	Good idea	97.2	92.6	95.3
		Poor idea	2.4	3.4	2.8
	Interview #2 - What do you think of minimum speed limits?	Don't know	0.4	4.0	1.9

Table 6-V

ROADSIDE INTERVIEW RESPONSES

	Question	Response Classifications	Interview #1 East Bound	Interview #2 West Bound	Combined
No. 5	Interview #1 - Do you think 45 m.p.h. is the proper minimum for this highway?	Less than 45 m.p.h.	2.0	1.4	1.7
		45 m.p.h.	62.0	53.1	58.4
	Interview #2 - If you were setting the minimum speed limit on a highway such as this at what speed would you set it?	More than 45 m.p.h.	32.8	41.8	36.5
		Don't know	3.2	3.7	3.4

Note: Figures in this table represent percentage of entire sample.

percentage of vehicles travelling less than 45 m.p.h. at section 12 but station 5 data indicated a corresponding decrease. There is not conclusive evidence here that slow moving traffic was diverted to the alternate route.

An attempt was made to establish this possible effect by a "before" and "after" traffic count on the alternate route. Counters were set out at two locations in mid October 1964. Three full weeks of counts were taken and the average daily traffic for the period was 580 vehicles. The three week count was repeated in January 1965 dur- the test period and yielded an average daily count of 435 vehicles per day. Reference to the permanent counting station indicates an expected seasonal decrease of 15% between these two time periods. This means that the normal expected daily volume on the alternate route was 85% x 580 = 494 v.p.d. It was obvious, therefore, that traffic was not diverted to the alternate route to any appreciable extent.

ROADSIDE INTERVIEWS

The percentage responses to the four roadside interview questions were listed in Table 6-V. The responses to question 2 indicated that only 10% of drivers were unaware or were misinformed about the maximum speed limit whereas 56% seemed unaware of the minimum speed despite exposure to 7 or 8 signs prior to the interview. It should be remembered, however, that the question was asked exactly as written and some of the drivers simply never associated the minimum as a speed limit, although they were aware of its existence.

The responses to question 3 indicate that only 9% of drivers felt they had adjusted speed because of the minimum limit. This adjustment was not reflected in the spot speed measurement results. The percentage of daytime traffic travelling under the 45 m.p.h. limit corresponded in a general way to the percentage of drivers answering "yes" to question 3.

Although only a small percentage of drivers were affected by the minimum speed limit a very large percentage (95%) were of the opinion that minimums should be used in this way. The interviews were conducted a full year after installation of the speed law. The repeat drivers had, therefore, plenty of opportunity to observe the ineffectiveness of the limit. They apparently still had a favourable reaction. This was an expression of the general awareness of and concern over the slow driver problem.

More than half of the drivers interviewed believed that 45 m.p.h. was the proper level for a minimum speed limit and nearly 40% were of the opinion that a higher minimum would be more effective.

The change of wording in question 4 and 5 produced a decrease in "yes" answers of 5 and 9 percent. This indicated definite bias had been introduced through the use of leading questions.

ENFORCEMENT

Meetings were held with the R.C.M.P. traffic supervisor at the commencement and during the test period. No concentration of enforcement

was initiated but the patrol personnel were advised to enforce the minimum speed limit to the same degree that they would other traffic laws. No enforcement was levelled at such vehicles as farm implements incapable of maintaining speed,and the limit was considered to be not in effect during inclement weather. It is common practice in most speed surveys to assume that enforcement has had no appreciable effect. Michaels (39) found that any results of enforcement on traffic behaviour were quite indirect.

Soon after testing began,an application was received from the Canadian Army requesting immunity from the minimum speed law for vehicles in convoy. The Manitoba Traffic Board denied this request and brought the existence of the alternate route to the attention of the applicants.

The police reported some difficulty in practical enforcement. Mentioned specifically were: 1) tolerance for speedometer error required enforcement at the 40 m.p.h. level which was too low, 2) traffic was probably hindered as much by a vehicle at 45 m.p.h. as it was by slower vehicles. The minimum limit made it difficult to prosecute these drivers under the general "impeding traffic" law, 3) certain drivers had speed restrictions less than 45 m.p.h. on their drivers licenses.

The enforcement level maintained throughout the test period was reported to be about 1.5 prosecutions per week. General comments from police officials were that although no improvement in the traffic situation had been noticed the public seemed to be in favour of the minimum.

PUBLICITY

No campaign was launched to bring the initiation of the minimum speed zone to the public attention. There were, however, some press releases such as that shown in FIGURE 6.19. In general, the highway signing was relied upon to give the message to the public.

DISCUSSION OF TEST RESULTS

The results of daytime speed measurements showed a remarkably consistent indication that an increase occurred in the lower speeds, and that the dispersion of speeds decreased after installation of the minimum speed limit. The changes took place, however, on the control section usually to as great a degree as they did on the test section.

The possibility existed that the effects of the regulation on the test section were carried over to the control section through the memory of drivers. This was considered unlikely since in the 11 miles separating the two sections there were about 2 miles of urban driving through the City of Portage la Prairie. In any case the carry-over reactions would affect only one-half of the vehicles on the control section since traffic was bound both ways. Changes in speed patterns on the control section should, therefore, have been one-half of the changes on the test section if the carryover effect had been operative.

Apparently the daytime speed changes were due to some other factor than the minimum speed limit.

New attention focused on the slow driver

A campaign is shaping which may make the Sunday driver more answerable to the law.

Police and safety officials have agreed for years that the man who drives too slowly on the highway causes accidents.

But, it's been impossible to do much about the situation because there's no minimum speed limit on provincial roads.

Now, these developments have occurred:

- The Manitoba government is experimenting with a minimum speed of 45 mph on a strip of highway to see how drivers react.
- A U.S. government agency says an extensive survey into accidents shows they are caused by drivers who fail to maintain the average speed of the rest of the cars on the road.

In other words, says the report, the very fast and the slow driver are the ones that cause the most accidents — but more so the slow driver.

HIGH HORSEPOWER

The study, made by the Bureau of Public Roads, says high horsepower and fast driving are not necessarily the marks of a killer, but rather poor acceleration while operating at highway speeds.

- Meanwhile, the Greater Winnipeg Safety Council, in conjunction with the Manitoba Medical Association, wants the province to subsidize a professional study of accident cause — including slow driving — in Manitoba.

'I'm meeting with Maitland Steinkopf (minister of public utilities and head of the Legislature's committee on highway safety) on Jan. 14," said Phil Haffner, director of the council.

Right now, the province is using the stretch of highway between Headingly and Portage la Prairie to study the effects of a minimum speed — posted underneath maximum speed limits — on the everyday and Sunday driver.

Members of the department of public works, says assistant deputy minister L. W. Blackman, are using radar equipment in their own autos to compile statistics on how drivers are reacting to the minimum speed limit.

Mr. Blackman said the study was begun when his department found out there had been no formal analysis of how slow drivers affect highway traffic.

Statistics on how many motorists have been convicted of driving slow — under section 70-5 of the Highway Traffic Act — are unavailable.

Neither Winnipeg Police traffic division, the RCMP nor the Manitoba Motor Vehicles Branch have separate figures on the offence because there have been so few convictions.

However, the RCMP and other officials admit that the number of convictions for slow driving are no indication of how big the problem is.

"Enforcement officers," said one official "simply have to overlook the problem unless the situation is very obvious; because they know it's very difficult to gain a conviction in court."

Asked senior crown prosecutor John Enns: "How do you judge a man's judgment."

What he meant by that was that without a minimum speed limit, a magistrate or judge would have to decide a case whether or not the driver was exercising good judgment in driving slower.

"But with a minimum speed limit, just as with a maximu "the law would be clear," said an RCMP official.

PRESS CLIPPING
WINNIPEG TRIBUNE
JANUARY · 4 · 1965

Figure : 6 · 19

The results of night speed measurements showed significant increased speeds in the low range, and a significant increase in mean speeds which could be attributed to the minimum speed limit. It was noted that the increases in the 15 percentile and mean speeds were of the order 1.5 to 2.0 m.p.h. but the corresponding values on the control section showed a 2.5 to 3.0 m.p.h. decrease making the increases significant in the practical sense. These changes were accompanied by a significant improvement in the normality of the speed distribution as tested by the skewness index. The beneficial effects of the change in normality are partially borne out by a lower increase in the proportion of night accidents.

An explanation of why these effects were evident at night might lie in one or both of the following directions. Firstly, is the possibility that the proportion of slow moving traffic was greater at night before the test and included more vehicles easily capable of increasing speed. Secondly, it is possible that the brilliance of the signs with their white reflectorized background brought the message more forcibly to drivers' attention at night, and as a consequence produced a speed adjustment.

The overtaking index was found to be a reliable measure of passing activity when related to speed dispersion factors and accidents during passing.

Roadside interviews revealed that 95% of drivers had a favourable opinion of minimum speed laws, although only 9% admitted being

affected by the 45 m.p.h. limit.

The natural question arising from these results was; "How could the public be so overwhelmingly favourable towards a system of control that had such scant effect on their driving habits?" The following might be a reconstruction of the public reasoning process:

1. The slow driver is a menace causing irritation, delay and hazard to other highway users.
2. A minimum speed limit will cause slow drivers to increase speed to nearer the average.
3. The result will be safer, more efficient traffic movement.
4. Therefore minimum speed limits are a good thing.

The results of this test indicated that point No. 2 of the reasoning process was faulty since the speed adjustment did not take place.

Because of the limits of statistical accuracy in the accident data occasioned by the one year restriction in "after" records, no definite conclusion could be drawn as to the effects of the minimum speed limits on accident occurrence. With these reservations in mind it was noted that there was no apparent overall effect on the accident rates. Increases occurred on both test and control sections. There was a stronger shift to more night accidents on the control section than on the test section.

No evidence was found to indicate that measureable amounts of traffic desiring to travel at slow speeds had used the alternate route.

This indicates that tests of this nature could be made where no alternate route existed without expectation of a material change in traffic conditions.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The aim of this research was to evaluate the effectiveness of a minimum speed limit on a two lane highway. The evaluation was principally made through comparison of before and after studies of spot speed measurements, travel time measurements and accident records. A sample of public opinion was obtained through roadside interviews.

From the tests performed the following are specific conclusions:

1. No effect on the percentage of vehicles travelling below the minimum speed limit was detected in daytime.
2. A decrease in the percentage of vehicles travelling below the minimum speed limit was detected at night.
3. No change was detected in the daytime mean operating speeds resulting from the minimum speed limit.
4. The minimum limit resulted in an increase in nighttime mean operating speeds.
5. No effect of the minimum speed limit on the dispersion of operating speeds about the mean speed either for day or night travel was detected.
6. The minimum speed limit did not affect the normality of the daytime speed distribution where the index of skewness was used as the measure of normality.

7. The night speed distribution was normalized as a result of the minimum speed limit, using the index of skewness as the measure of normality.
8. The driving public had a favourable opinion of minimum speed limits.

As a result of experience gained through this investigation, and as a consequence of the findings therefrom the author offers the following recommendations:

1. It is recommended that, because they have slight effect, minimum speed limits should not be used as a device for controlling operating speeds of traffic on two lane highways.
2. The value of night time minimum speed limits should be investigated further to establish firstly, whether improvements in the speed patterns which were found in this investigation are general in effect or are peculiar to the test highway, and secondly the possible relationship between improved night safety and minimum speed limit, suggested by the results of this test.

   Such an investigation could be designed to eliminate the possible effects of changes to the night maximum speed limit which may have affected these test results.
3. The effectiveness of minimum speed limits on multi-lane highways and freeways should be established using methods similar to those used in this test.

4. Research is recommended into the effect of varying the numerical minimum speed limit.
5. The Index of Overtaking as developed in this project is recommended for use as a measure of passing activity on two lane highways.

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APPENDIX A

TEST PROCEDURES

SPOT SPEED MEASUREMENTS

Equipment - a "Muni-Quip" radar speed timer was used for all spot speed measurements. One hundred feet of lead wiring allowed installation of the antenna remote from the test vehicle. The antenna was mounted on a sign post located near the test stations. If there were not existing posts near the station special route marking signs were installed to carry the antenna.

Speeds of traffic in both directions were taken from one side of the highway. This means that with 10 foot shoulders the antenna was laterally displaced, about 30 feet from the centre line of the far lane. With a range of 1500 feet all vehicles were well within the 10° spread of the broadest beam resulting in well defined readings.

The test vehicle was a standard light coloured Ford sedan. Two heavy duty 12 volt batteries were the power source for the unit and were permanently installed in the trunk of the car. The batteries were used alternate days and were recharged overnight with a trickle charger installed in the vehicle. The operator was supplied with a hand counter so as to be able to record the sample size taken.

PROCEDURE

FIGURES A.1 and A.2 show the test vehicle and antenna mounting at station No. 12 on the alternate route.

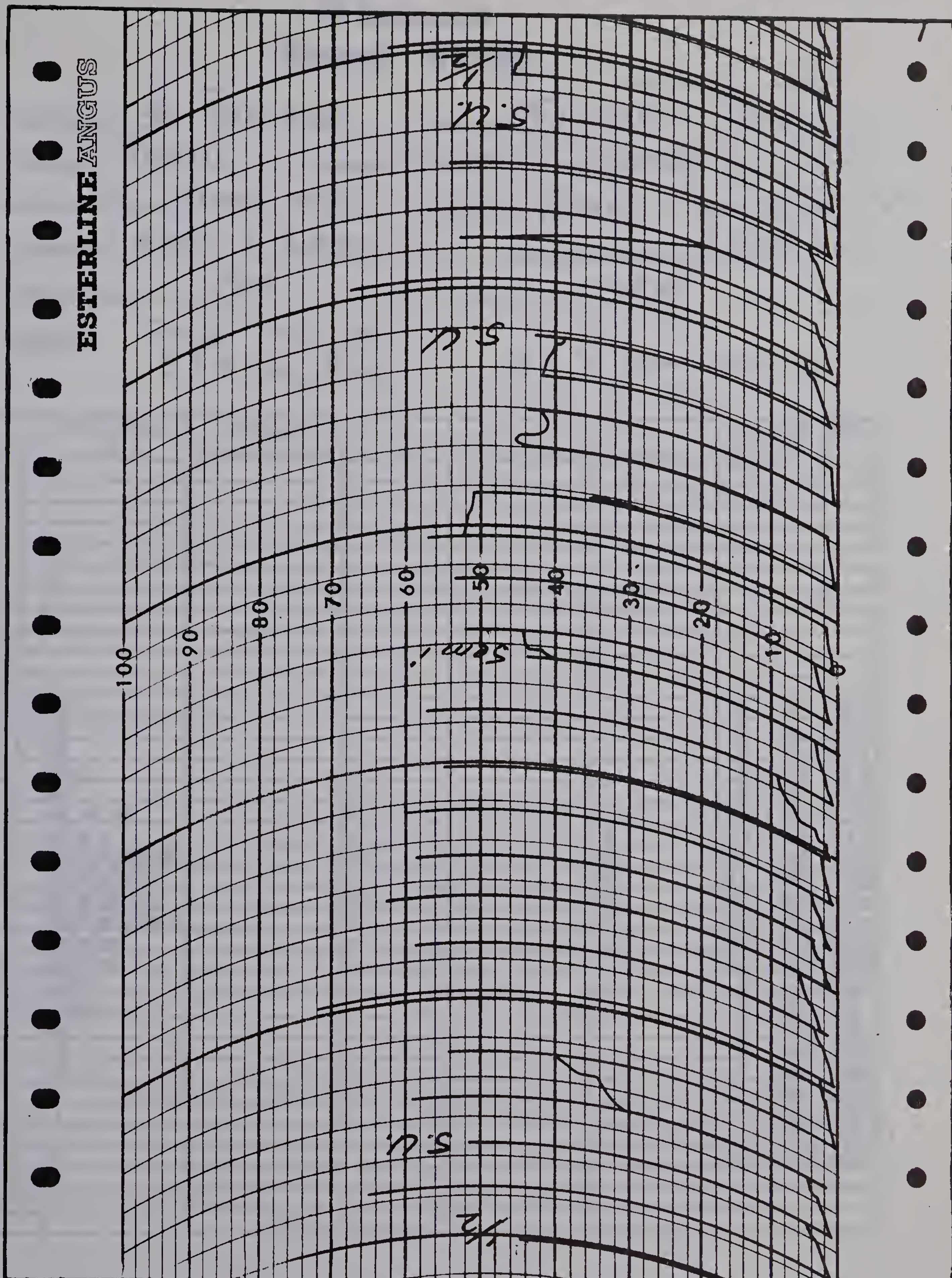
FIGURE A.1 TEST VEHICLE ON LEFT PARKED INCONSPICUOUSLY

Speed records were kept by means of the Esterline-Angus chart recorder. This is shown in FIGURE A.3 as it was installed in the test vehicle. The operator made his notes directly on the chart, identifying half-ton, single unit and tractor-trailer trucks. FIGURE A.4 shows a portion of the chart record taken at station No. 8. This information was later transferred to speed study data sheets such as shown in FIGURE A.5 and from these the cumulative frequency curves were plotted.

Care was taken that the test vehicle was hidden as much as possible from approaching traffic but in such a position that the observer could clearly see passing vehicles. Where screening was not possible from trees or driveways the vehicle was parked parallel to

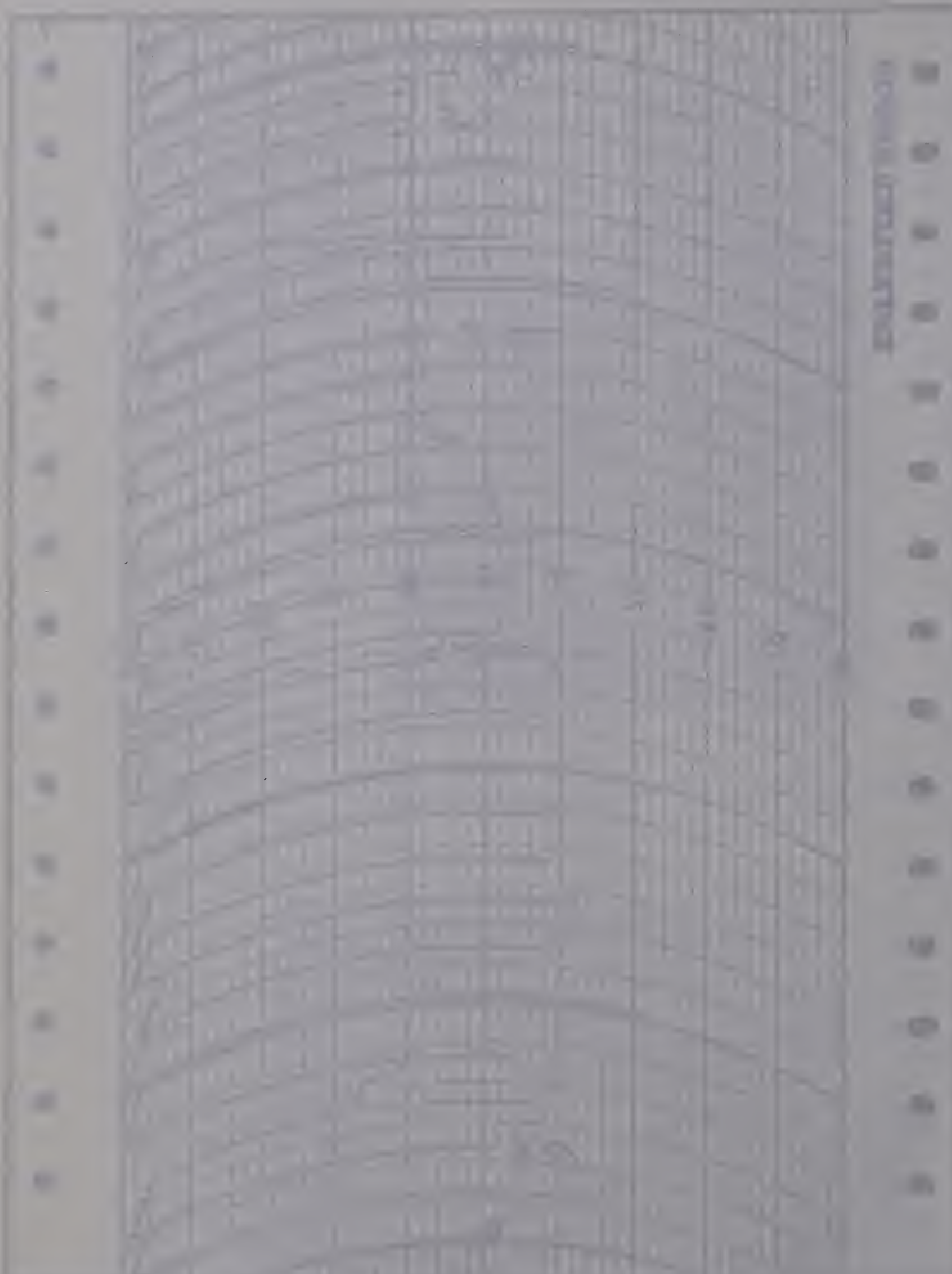
FIGURE A.2 TYPICAL POST MOUNTED ANTENNA

FIGURE A.3 CHART RECORDER IN TEST VEHICLE



PORTION OF RADAR CHART
STATION Nº. 8

Figure: A·4



Minimum
Speed Study

Highway No. 4 PORTAGE ...... Location (5) FACING WEST NORTH SIDE ....

Observer BURNS ...... Weather CLOUDY .... Date Oct 23 . Time 1 P.M. 4 P.M. ..

Surface: Type BLACK TOP ...... Condition GOOD ..... Width 2-12'-3's.

Direction EAST & WEST .... Existing Limit 60 MPH ..

Sample Size 265 .... Flow FREE ....

Remarks: PACE 47-57
59% in PACE 21% COMMERCIAL

M.P.H.	Passenger Cars	Foreign Passenger Cars	½ Tons	Single Unit	Semis	TOT.	CUM. TOT.	CUM. %
0-12.9								
13-14.9								
15-16.9								
17-18.9								
19-20.9								
21-22.9								
23-24.9								
25-26.9								
27-28.9								
29-30.9								
31-32.9								
33-34.9	//					2	2	0.5
35-36.9	///			/		4	6	2.5
37-38.9	////					4	10	3.5
39-40.9	卌 //		//			9	19	7.5
41-42.9	卌		//	/		8	27	10.5
43-44.9	卌 卌 卌		///			18	45	17.0
45-46.9	卌 卌 //		//	/	//	17	62	23.5
47-48.9	卌 卌 卌 卌 卌 卌 /		///	/	卌	41	103	39.0
49-50.9	卌 卌 卌 卌 ///		//	//	////	31	134	50.5
51-52.9	卌 卌 卌 卌 //		////	/	///	30	164	62.0
53-54.9	卌 卌 卌 卌 卌 //		//	/	卌	35	199	75.0
55-56.9	卌 卌 卌		//	/	//	20	219	82.5
57-58.9	卌 卌 ///		/	/		15	234	88.5
59-60.9	卌 /		/		/	8	242	91.5
61-62.9	卌 //					7	249	94.
63-64.9	卌 /					6	255	96.
65-66.9	///					3	258	97.5
67-68.9	//					2	260	98.
69-70.9	/					1	261	98.5
71-72.9	/					1	262	99.
73-74.9	/					1	263	99.5
75-76.9	//					2	265	100.
77-78.9								
79-80.9								
81+								

SPEED STUDY
DATA SHEET

Figure: A·5

the direction of travel so as to present a smaller silhouette.

Accuracy of readings were checked at each setup by means of a calibrated tuning fork whose vibrations simulated a 60 m.p.h. vehicle. In addition, occasional checks were made using police vehicles with calibrated speedometers.

In order to avoid sample bias all daytime studies were done on weekdays when weather and traffic conditions were normal. The study hours were from 9 a.m. to 4 p.m. Night studies were taken in early hours of darkness from about 7 p.m. Most of the spot speed measurements were recorded in October, November and March when daily traffic volumes were fairly constant.

TRAVEL TIME MEASUREMENTS

Two test vehicles were used for these measurements and were stationed at either end of the roadway section under study. Watches were synchronized at the beginning of the test and passage of vehicles was recorded to the nearest minute along with the last three digits of the vehicle license.

The information was recorded on the data sheet shown on FIGURE A.6, the license numbers matched and travel time and average speed of each vehicle was calculated.

In addition, the order in which vehicles entered and left the test course were compared and the number of passing manoeuvres involving through vehicles were computed.

MINIMUM SPEED STUDIES

DATE Nov. 24.64 LOCATION Test Section WEATHER Fine BY Malloy and Jardine

Licence Nº	TIME		Finish Time	Travel Time	Average Speed
	East Bound	West Bound			
371	10:27		From Page 2		
B14	27		10:59	32	62
619	27		11:00	33	60
U21	27		10:56	29	68
Semi 719	29		11:03	34	58
G41	31				
216	31				
554	33		11:10	37	54
G90	34				
3A9	36		10:59	23	86
Semi Security	36				
2237	36				
994	36		11:09	33	60
BA6	37		11:09	32	62
G47	37		11:10	33	60
G91	37				
Semi 616	41		11:18	37	54
321	41				
416	41		11:14	33	60
397	41		11:14	33	60
221	42		11:15	33	60
900	45		11:17	32	62
H40	46				
G55	46		11:38	52	38
R27	46				
T317	50		11:38	48	41
956	50				
Semi 781	51		11:25	34	58
406	51				
G20	53				
127	53		11:21	28	71
T67016	55		11:31	36	55
277	59				
A14	10:59		11:25	26	76
B61	11:00		11:25	25	79
G62	11:00				
644	01				
892	01				
411	02				
309	02		11:41	39	51

TRAVEL TIME
DATA SHEET

Figure : A·6

FIGURE A.7 THE INTERVIEW TEAM

FIGURE A.8 ALL TRAFFIC IS INTERVIEWED

ROADSIDE INTERVIEWS

The interview technique involved stopping all traffic and asking 5 questions. Five interviewers were used allowing periodic breaks in rotation. Advance warning was given traffic using two signs TRAFFIC INTERVIEW 1000 Ft. and BE PREPARED TO STOP. A line of cones and two police officers were used to guide traffic to the interview area. FIGURES A.9 and A.10 illustrate the method used to stop vehicles. Vehicles were channeled onto the shoulders so that interviewers could stand on the drivers' side without being endangered by oncoming traffic. FIGURE A.11 shows the data sheet used and the method of totalling the results.

FIGURE A.9 ADVANCE WARNING SIGN

FIGURE A.10 PLACEMENT OF SIGN, CONES AND POLICE OFFICERS

Sheet 2 of 6

MANITOBA HIGHWAYS

Minimum Speed Limit Roadside Interview

Test Section

Date Oct. 14. 65

Interviewer Boychuk

Direction of Traffic W. Bound

	commercial	Q. № 1 WHAT IS YOUR DESTINATION ?		Q. № 2 WHAT ARE THE SPEED LIMITS ON THIS HIGHWAY ?				Q. № 3 DID YOU INCREASE SPEED BECAUSE OF the Minimum Speed Limit ?			Q. № 4 What do you think of Minimum Speed Limits ?			Q. № 5 If you were setting the Minimum Speed Limit on a road such as this, at what speed would you set it ?			
		Local	Distant	Correct	Maximum Correct	Minimum Correct	Incorrect, or don't know	Yes	No	Don't Know	Favorable	Unfavorable	Don't Know	under 45	45	over 45	don't know
1		✓		✓					✓		✓					✓	
2	✓		✓	✓					✓		✓					✓	
3		✓			✓				✓		✓				✓		
4		✓			✓					✓	✓				✓		
5	✓		✓	✓				✓					✓				✓
6		✓		✓					✓		✓				✓		
7		✓		✓					✓		✓					✓	
8	✓		✓		✓				✓				✓				✓
9		✓		✓				✓			✓				✓		
10		✓		✓					✓		✓					✓	
11		✓		✓					✓		✓				✓	✓	
12		✓					✓		✓		✓						
13		✓			✓				✓		✓					✓	
14		✓			✓				✓			✓			✓		
15		✓		✓					✓		✓				✓		
16		✓			✓				✓		✓				✓		
17	✓	✓		✓					✓		✓					✓	
18			✓		✓				✓		✓			✓			
19	✓		✓		✓					✓			✓				✓
20		✓			✓				✓		✓				✓		
21		✓			✓				✓		✓				✓		
22		✓		✓					✓		✓				✓		
23		✓		✓					✓		✓				✓		
24			✓	✓					✓		✓				✓		
25		✓		✓					✓		✓				✓		
total		19	6	14	10	–	1	2	21	2	21	1	3	1	14	7	3
%		76	24	56	40		4	8	84	8	84	4	12	4	56	28	12

INTERVIEW
DATA SHEET

Figure : A·11

APPENDIX B

DATA & CALCULATIONS

Table B-I

SPOT SPEED DATA SUMMARY

STATION #1 CONTROL SECTION

Date	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Mar. 65	Nov. 65
Before/After	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Night	Night	Night
85%	57.0	59.0	56.5	59.5	62.0	55.0	59.0
15%	44.0	47.0	44.5	48.5	46.5	42.0	46.5
Differential	13.0	12.0	12.0	11.0	15.5	13.0	12.5
50%	51.0	53.0	50.0	54.5	54.0	48.0	53.0
% < 45	19.0	9.0	17.0	7.0	11.5	32.5	11.0
Pace	47-57	49-59	47-57	51-61	49-59	43-53	49-59
% in Pace	58.0	60.5	61.0	66.0	48.5	47.5	59.0
% Trucks	13	15	26	12	20	20	8

Table B-II

SPOT SPEED DATA SUMMARY

STATION 2 CONTROL SECTION

Date	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Mar. 65	Oct. 65
Before/After	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Night	Night	Night
85%	57.5	60.0	56.0	58.0	61.0	54.0	57.5
15%	44.0	46.5	45.0	44.5	46.5	42.5	44.5
Differential	13.5	13.5	11.0	13.5	14.5	11.5	13.0
50%	51.0	53.5	50.5	53.0	54.0	47.5	51.0
% < 45	18.0	9.5	15.0	17.0	10.0	30.0	17.0
Pace	47-57	49-59	47-57	49-59	51-61	45-55	47-57
% in Pace	58.0	54.0	64.5	60.0	54.5	64.0	56.0
% Trucks	12	11	21	19	14	19	15

Table B-III

SPOT SPEED DATA SUMMARY

STATION 3 CONTROL SECTION

Date	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Mar. 65	Oct. 65
Before/After	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Night	Night	Night
85%	54.0	60.0	56.5	59.5	59.0	58.0	58.5
15%	40.5	49.0	44.5	50.0	45.0	47.0	46.5
Differential	13.5	11.0	12.0	9.5	14.0	11.0	12.0
50%	47.5	54.5	50.5	55.0	52.0	52.5	53.0
% < 45	36.0	6.0	17.5	4.5	15.0	10.5	10.5
Pace	43-53	49-59	47-57	51-61	47-57	49-59	51-61
% in Pace	57.0	61.0	60.0	72.0	54.5	66.5	59.0
% Trucks	13	12	18	5	14	17	6

Table B-IV

SPOT SPEED DATA SUMMARY

STATION 4 CONTROL SECTION

Date	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Mar. 65	Oct. 65
Before/After	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Night	Night	Night
85%	55.0	61.5	56.0	55.5	60.0	58.0	55.5
15%	41.5	50.0	43.0	47.0	48.0	46.0	42.5
Differential	13.5	11.5	13.0	8.5	12.0	12.0	13.0
50%	49.0	56.0	49.5	51.0	54.5	52.0	49.5
% < 45	26.0	4.5	25.0	7.5	8.0	11.0	25.0
Pace	45-55	51-61	45-55	47-57	51-61	47-57	45-55
% in Pace	59.5	62.0	60.5	75.5	60.0	60.0	58.5
% Trucks	20	16	18	7	16	14	18

Table B-V

SPOT SPEED DATA SUMMARY

STATION #6 TEST SECTION

Date	Nov. 64	Oct. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Jan. 65	Nov. 65
Before/After	Before	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Night	Night	Night
85%	61.0	59.5	59.5	59.0	60.5	57.0	56.5	57.0
15%	47.5	46.0	47.5	47.5	49.5	46.0	44.5	46.5
Differential	13.5	13.5	12.0	11.5	11.0	11.0	12.0	10.5
50%	54.5	53.0	53.0	53.5	55.0	51.0	50.5	52.5
% < 45	10.0	13.0	7.5	7.5	3.5	12.0	15.0	11.0
Pace	51-61	51-61	49-59	49-59	51-61	47-57	47-57	49-59
% in Pace	56.0	56.5	61.5	62.5	66.0	65.0	59.5	65.0
% Trucks	20	-	14	11	3	14	20	20

Table B-VI

SPOT SPEED DATA SUMMARY

STATION #7 TEST SECTION

FOR SOUTH SIDE FACING WEST

Date	Oct. 64	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Jan. 65	Nov. 65
Before/After	Before	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Night	Night	Night
85%	58.5	61.0	56.5	59.5	58.0	58.0	59.5	51.5
15%	47.0	48.0	43.5	49.0	46.0	44.5	46.5	41.5
Differential	11.5	13.0	13.0	10.5	12.0	13.5	13.0	10.0
50%	53.0	54.5	50.5	54.0	53.0	51.0	54.5	46.5
% < 45	10.0	6.5	21.0	5.0	13.0	18.5	5.5	36.0
Pace	49-59	51-61	47-57	51-61	49.0	45.0	51.0	43.0
% in Pace	60.5	58.5	57.0	65.0	43.5	57.0	67.0	67.0
% Trucks	-	19	24	21	19	8	7	12

Table B-VII

SPOT SPEED DATA SUMMARY

STATION #7 TEST SECTION

FOR SOUTH SIDE FACING EAST

Date	Nov. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Jan. 65	Nov. 65
Before/After	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Night	Night	Night
85%	55.5	56.5	58.5	59.0	55.0	58.5	54.5
15%	44.5	45.5	47.0	45.0	44.5	47.5	43.0
Differential	11	11	11.5	14.0	10.5	11.0	11.5
50%	50.0	50.5	53.5	52.5	50.0	53.0	49.0
% < 45	16.5	11.5	10.0	15.0	16.5	9.0	23.5
Pace	47-57	45-55	49-59	49-59	45-55	47-57	45-55
% in Pace	67.5	64.5	62.0	55.0	68.0	62.5	63.0
% Trucks	22	17	20	18	9	9	17

Table B-VIII

SPOT SPEED DATA SUMMARY

STATION #8 TEST SECTION

Date	Jul.62	Sept.62	Jan.64	Oct.64	Nov.64	Dec.64	Mar.65	Oct.65	Jul.64*	Nov.64	Jan.65	Oct.65
Before/After	Before	Before	Before	Before	Before	After	After	After	Before	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Day	Day	Day	Night	Night	Night	Night
85%	61.0	59.0	59.0	58.5	59.5	59.5	60.5	58.5	56.0	52.5	56.5	56.5
15%	48.5	45.5	45.5	45.5	47.5	48.0	49.5	45.0	44.0	41.0	44.0	45.5
Differential	12.5	13.5	13.5	13.0	12.0	11.5	11.0	13.5	12.0	11.5	12.5	11.0
50%	54.0	53.5	52.5	52.0	53.5	53.5	54.5	52.0	50.0	47.0	50.5	52.0
% < 45	5.5	13.5	14.0	13.0	8.5	7.0	5.0	14.0	19.0	37.0	18.5	13.0
Pace	49-59	51-61	49-59	47-57	51-61	49-59	51-61	51-61	45-55	43-53	47-57	47-57
% in Pace	60.5	54.0	54.5	59.0	58.0	62.0	66.0	57.0	60.5	61.0	61.0	63.0
% Trucks	10	19	30	16	21	18	23	20	-	13	23	26

* Night Maximum Speed Limit 50

Table B-IX

SPOT SPEED DATA SUMMARY

STATION #9 TEST SECTION

Date	Nov. 64	Oct. 64	Dec. 64	Mar. 65	Oct. 65	Nov. 64	Jan. 65	Nov. 65
Before/After	Before	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Night	Night	Night
85%	62.0	55.5	58.5	58.0	58.0	55.0	58.0	54.5
15%	49.5	44.5	48.0	47.0	47.5	45.0	48.5	43.5
Differential	12.5	11.0	10.5	11.0	10.5	10.0	9.5	11.0
50%	56.0	50.0	53.5	53.0	54.0	50.0	53.0	48.5
%<45	5.5	18.0	7.5	11.0	8.0	15.0	6.0	24.5
Pace	53-63	47-57	49-59	49-59	49-59	45-55	49-59	43-53
% in Pace	57	65	66.5	65.5	70.5	68.0	69.5	61.0
% Trucks	17	-	20	23	11	21	13	40

Table B-X

SPOT SPEED DATA SUMMARY

STATION #10 TEST SECTION

Date	Jul.62	Oct. 64	Nov. 64	Dec.64	Mar.65	Oct.65	Nov.64	Jan.65	Oct.65
Before/After	Before	Before	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Day	Night	Night	Night
85%	58.5	57.0	59.5	59.0	59.5	57.0	53.0	58.5	55.5
15%	46.5	46.5	47.0	45.0	47.0	47.5	42.5	47.0	44.0
Differential	12.0	10.5	12.5	14.0	12.5	9.5	10.5	11.5	11.5
50%	52.5	52.0	53.0	52.5	53.5	52.5	47.5	53.0	49.5
% < 45	10.0	9.0	10.0	15.0	9.5	8.0	32.0	9.5	21.0
Pace	49-59	49-59	49-59	49-59	51-61	49-59	43-53	49-59	45-55
% in Pace	58.5	64.2	60.0	53.5	59.0	68.0	64.5	62.5	62.0
% Trucks	14	22	-	21	17	4	14	23	18

Table B-XI

SPOT SPEED DATA SUMMARY

STATION #11 TEST SECTION

Date	Oct.64	Nov.64	Dec.64	Mar.65	Oct.65	Nov.64	Jan.65	Nov.65
Before/After	Before	Before	After	After	After	Before	After	After
Day/Night	Day	Day	Day	Day	Day	Night	Night	Night
85%	57.0	58.0	59.0	59.5	61.5	53.0	58.5	55.5
15%	42.0	44.5	47.5	49.0	47.5	42.0	46.5	42.5
Differential	15.0	13.5	11.5	10.5	14.0	11.0	12.0	13.0
50%	51.0	51.0	53.0	54.5	55.0	47.0	52.0	50.5
% < 45	24.0	16.5	8.0	6.5	8.0	36.0	9.5	22.0
Pace	49-59	47-57	49-59	51-61	51-61	43-53	49-59	47-57
% in Pace	56.5	53.5	54.0	66.5	54.0	66.5	63.5	60.5
% Trucks	29	-	15	18	28	14	15	22

Table B-XII

SPOT SPEED DATA SUMMARY

ALTERNATE ROUTE

	STATION 5				STATION 12			
Date	Nov.64	Dec.64	Mar.65	Oct.65	Nov.64	Dec.64	Apr.65	Oct.65
Before/After	Before	After	After	After	Before	After	After	After
Day/Night	Day	Day	Day	Day	Day	Day	Day	Day
85%	53.0	56.0	53.5	56.5	55.5	57.0	52.5	55.5
15%	39.5	39.0	40.0	43.5	40.0	40.0	34.0	37.5
Differential	13.5	15.0	13.5	13.0	15.5	17.0	18.5	18.0
50%	46.0	48.0	47.0	50.0	47.5	49.5	44.5	46.5
% < 45	46.0	36.0	36.0	21.5	37.0	30.0	52.0	43.0
Pace	41-51	43-53	45-55	47-57	43-53	47-57	41-51	43-53
% in Pace	53.5	46.0	57.5	59.0	51.0	48.5	46.5	43.0
% Trucks	24	14	17	21	18	21	22	30

x	f	f (x)	x²	f x²	x - x̄	(x - x̄)²	(x - x̄)³	f(x-x̄)²	f(x-x̄)³
26	2	52	676	1252	-28.4	807	-22906	1614	-45812
28	3	84	784	2352	-26.4	697	-18400	2091	-55200
30	2	60	900	1800	-24.4	595	-14526	1190	-29052
32	5	160	1024	5152	-22.4	502	-11239	2510	-56195
34	11	374	1156	12,716	-20.4	416	-8489	4576	-93379
36	12	432	1296	15552	-18.4	339	-6229	4068	-74748
38	25	950	1444	36100	-16.4	269	-4411	6725	-110275
40	40	1600	1600	64000	-14.4	207	-2985	8280	-119400
42	65	2730	1764	114660	-12.4	154	-1907	10010	-123955
44	80	3520	1936	154880	-10.4	108	-1125	8640	-90000
46	173	7958	2116	366068	-8.4	71	-593	12283	-102589
48	253	12144	2304	582912	-6.4	41	-262	10373	-66286
50	291	14550	2500	727500	-4.4	19	-85	5529	-24735
52	428	22256	2704	1,157,312	-2.4	6	-14	2568	-5992
54	491	26514	2916	1,437,756	-0.4	—	—	—	—
56	599	33544	3136	1,878,464	+1.6	3	+4	1797	+2396
58	455	26390	3364	1,530,620	+3.6	13	+46	5915	+20930
60	293	17580	3600	1,054,800	+5.6	31	+175	9083	+51275
62	200	12400	3844	768,800	+7.6	57	+439	11400	+87800
64	101	6464	4096	413,696	+9.6	92	+884	9292	+89284
66	69	4554	4356	300564	+11.6	135	+1561	9315	+107709
68	42	2856	4624	194208	+13.6	185	+2515	7770	+105630
70	24	1680	4900	117,600	+15.6	243	+3796	5832	+91104
72	9	648	5184	46,656	+17.6	310	+5452	2790	+49068
74	5	370	5476	27,380	+19.6	384	+7529	1920	+37645
76	4	304	5776	23,104	+21.6	467	+10078	1868	+40312
78	1	78	6084	6084	+23.6	557	+13144	557	+13144
80	1	80	6400	6400	+25.6	655	+16777	655	+16777
TOT.	3684 = N	200332		11,042,356				148,651	-284544

$\overline{X} = \frac{\Sigma f(X)}{N} = \frac{200,332}{3,684} = 54.4$ m.p.h $S = \sqrt{\frac{\Sigma f(X)^2 - N(\overline{X})^2}{N-1}} = \sqrt{\frac{11,042,356 - 3,684\,(54.4)^2}{3,683}} = 6.3$ m p h

$M_2 = \frac{\Sigma f(X-\overline{X})^2}{N} = \frac{148,651}{3,684} = 40.4$ $M_3 = \frac{\Sigma f(X-\overline{X})^3}{N} = \frac{-284,544}{3,684} = -77.2$

$a_3 = \frac{M_3}{\sqrt{M_2^3}} = \frac{-77.2}{\sqrt{(40.4)^3}} = -0.30$

SAMPLE CALCULATIONS
MEAN SPEED
STANDARD DEVIATION
SKEWNESS INDEX